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March 31, 2006

Attn: Chemical Right-to-Know Program
Administrator
US Environmental Protection Agency
P.O. Box 1473
Merrifield, VA 22116
(email: oppt.ncic@epa.gov, chem.rtk@epa.gov)

RE: Submission for HPV Challenge Program

Dear Sir or Madam:

Albemarle Corporation (sponsor registration # . .) is pleased to submit the attached Category Justification, Robust Summary, and Test Plan documents (in Word ".doc" format) for the "Higher Alkenyl Succinic Anhydride (ASA)" category of compounds (covered by the HPV chemicals with CAS#s 32072-96-l) #28777-98-2, and EHPV chemical with CAS# 53520-67-5), as a voluntary participant in the HPV Challenge Program and as part of our ongoing commitment to product stewardship.

As referenced in our December 28, 2005 commitment letter to the HPV Challenge program, we understand that EPA will continue to recognize these as viable commitments, and that if necessary, additional testing will be conducted in the time frame established by the US EPA HPV Challenge Program. We also understand that the information and data we provide under the HPV Challenge Program will be reviewed and made publicly available.

We would like to notify EPA that Albemarle Corporation has very recently been contacted by another major manufacturer of the "Higher ASAs", as well as by the CHEMSTAR Director at the American Chemistry Council (ACC), with a proposal to work together and share information and resources in the interest of generating a more complete dossier. As this new collaboration develops, we plan on amending additional commitment documents for the sponsored chemicals as necessary in the upcoming weeks.

The technical contact for this submission to the U.S. EPA HPV program is:

Dr. Len Sweet, PhD, MPH, MSc.
Albemarle Corporation
Health, Safety & Environment
451 Florida Street
Baton Rouge, LA 70801-l 765
225-202-3330 (phone)

Sincerely,

Len Sweet, **PhD,** MPH, **MSc.**
Global Product Stewardship Director

HigherASAsRobustSummaryMarch2006.doc HigherASAsCATEGORY JUSTIFICATIONMarch2006.doc

201-16228

Higher Alkenyl Succinic Anhydride (ASA) CATEGORY JUSTIFICATION and TEST PLAN

The American Chemistry Council Petroleum Additives Panel (Panel) Health, Environmental and Regulatory Task Group (HERTG) previously determined that several alkenyl succinic anhydride chemicals met the criteria for a chemical category (*Alkenyl Succinic Anhydride Category)* in the Environmental Protection Agency's High Production Volume (HPV) Chemical Challenge Program. The chemicals represented in that group were:

•2,5-Furandione,dihydro-3-(tetrapropenyl)-,(CAS #26544-38-7), referred to as "tetrapropenylsuccinic anhydride".

•Butanedioic acid,(tetrapropenyl)-,(CAS #27859-58-1), referred to as "tetrapropenyl butanedioic acid".

•2,5-Furandione,3-(dodecenyl)dihydro-,(CAS #25377-73-5), referred to as "dodecenylsuccinic anhydride".

In the HERTG test plan, CAS #25377-73-5 and CAS #26544-38-7 were considered interchangeable and refer to the same substance – a C12 alkenyl substituted succinic anhydride. Tetrapropenyl butanedioic acid (CAS #27859-58-1) was also included in the category because under many conditions the diacid form of the anhydride would be the form that existed in that media. For this reason, the anhydride and diacid were included together in the HERTG test plan, although they are chemically dissimilar.

Albemarle Corporation believes three other alkenyl succinic anhydrides (ASAs) could be considered in this category of chemicals, differing only in having alkenyl substituents longer than 12 carbons. These chemicals, also produced in high volumes, are:

2,5-Furandione, 3-(hexadecenyl)dihydro-, (CAS #32072-96-1), referred to as "hexadecenylsuccinic anhydride" or "C16 ASA".

2,5-Furandione, 3-(octadecenyl)dihydro-, (CAS #28777-98-2), referred to as "octadecenylsuccinic anhydride" or "C18 ASA"

2,5-Furandione, 3-(eicosenyl)dihydro-, (CAS #53520-67-5), referred to as "eicosenylsuccinic anhydride" or "C20 ASA".

Albemarle Corporation suggests the term "Higher" Alkenyl Succinic Anhydrides for these chemicals, similar to the naming of the "Higher Olefins Category" by the ACC Higher Olefin Panel for the HPV Challenge Program.

Structural Similarity. Structural similarity is a key factor in considering the alkenyl succinic anhydride and higher ASAs a category. Substances in this category consist of either a succinic anhydride structure or a butanedioic acid with an alkenyl substituent group. The anhydride can undergo hydrolysis to the corresponding butanedioic acid.

Although the previous HERTG submission for the ASA category referred primarily to ASAs with branched alkyl substituents, the chemicals for this "higher ASA" group are primarily linear chained alkenyl substituted succinic anhydrides. They differ from dodecenylsuccinic anhydride (DDSA) by having linear alkyl substitutions of carbon length 16 (C16), C18, or C20 instead of C12.

The commercially available "higher" ASA products are usually mixtures of these ASAs with various alkenyl lengths. For example, a C1618 ASA will contain C16, C18, and C20 alkenyl substituted succinic anhydrides.

Similarity of Physicochemical Properties. The similarity of several physicochemical properties of these chemicals is consistent with their similar structure. They have low volatility due to their low vapor pressure (typically <3E-4 Pa @25 °C), high viscosity (typically 200 cSt @25 °C), densities of approximately 1.0 g/ml (@25 °C), sparingly low water solubility (<10 mg/L based on calculated data),and molecular weights of 266.4 daltons for the C12 ASAs to 378.6 for the C20 ASA.

Fate and Transport Characteristics A member of the original category, tetrapropenyl butanedioic acid, was been shown to have limited biodegradability. Modeling of the linear alkyl chain substituents suggest that biodegradation could be more extensive. Existing information for the anhydride suggests it will undergo hydrolysis and will be the form that should be considered when evaluating environmental fate. Direct photodegradation is not expected to cause significant physical degradation of members in this category. However, computer-modeled data will be developed to adequately characterize their potential to oxidize as a result of hydroxyl (OH-) radical attack. These substances are not expected to significantly partition to air if released into the environment because of their relatively low vapor pressure. Computer-modeled environmental partitioning data will be calculated for members of this category to determine their potential to partition to other environmental compartments.

Toxicological Similarity. Review of reliable published and unpublished test data for members of the alkenyl succinic anhydride category and higher ASAs suggests that the toxicity profiles of these chemicals are similar. Data obtained from proposed additional testing by the HERTG panel will further characterize the toxicological endpoints in the HPV Challenge Program for all members within this and the higher ASA categories.

Aquatic Toxicology. Alga toxicity data for a member of the alkenyl succinic anhydride category was reviewed by the HERTG panel, and the findings indicated some toxicity when appropriate test methods were used. Additional testing was proposed by the

HERTG panel to more fully characterize the aquatic toxicity potential for members of the category. In addition, aquatic toxicity testing is available for a product that is a mixture of the higher C16, C18 and C20 alkenyl succinic anhydrides. This testing will be used to bridge to the other alkenyl succinic anhydrides.

Mammalian Toxicology –Acute Data on acute mammalian toxicity were reviewed by the HERTG panel, and they concluded the findings indicated a low concern for acute toxicity. Data are available for two members of the original category, and for a product that is a mixture of C16 and C18 alkenyl succinic anhydrides, indicating that the ASAs have been well tested for acute mammalian effects. Therefore, no additional acute mammalian toxicity testing is necessary.

Mammalian Toxicology -Mutagenicity. Valid data from bacterial reverse mutation assays and *in vitro* chromosome aberration studies were not located by the HERTG panel for the original group of ASAs in the category. Negative bacterial mutagenicity testing (Ames Test), and *in vitro* mammalian cell mutagenicity testing (unscheduled DNA synthesis) was available for a product that is a mixture of C16 and C18 alkenyl succinic anhydrides. This data will be used for bridging to the other chained alkenyl succinic anhydrides.

Mammalian Toxicology -Subchronic Toxicity. Valid data from repeated-dose toxicity studies were not located by the HERTG panel for the original category of ASAs nor by Albemarle Corporation for the higher ASAs.

Mammalian Toxicology -Reproductive and Developmental Toxicity Valid data from a reproductive/developmental toxicity screening study were not located by the HERTG panel for the original ASA category members, nor by Albemarle for the higher ASAs.

Conclusion. Based upon the data reviewed for this test plan, the physicochemical, environmental fate, and toxicological properties of original category members proposed by the HERTG panel, and the higher ASAs proposed by Albemarle Corporation are similar and/or follow a predictable pattern based on structure. (The original category contained an anhydride and its hydrolytic reaction product, which the HERTG panel believed could not be considered separately with regard to toxicity and environmental fate.) Therefore, the EPA definition of a chemical category has been met, and the three CAS numbers that constitute the higher alkenyl succinic anhydride category will be evaluated in accordance with the test plan summarized below. The three chemicals in the HERTG panel test plan will be used as reference, and data from the C1618 ASA product will be used as analogy for the higher ASA chemicals.

Test Plan. The test plan for the higher alkenyl succinic anhydride category includes the following testing, computer modeling, or technical discussions:

•**Physicochemical –** No further testing is proposed for the higher ASAs. Data from manufacturers, literature references, and modeling will be used. The water solubility of tetrapropenyl butanedioic acid (CAS #27859-58-1) will be determined by the HERTG panel test program. This data, when available, will be compared to the estimations for the higher ASAs, and need for further testing of the higher ASAs will be determined.

•**Hydrolysis**. The public and available private literature will be evaluated to determine whether there is sufficient information to adequately characterize the potential hydrolysis rate of the higher ASAs. Since the potential for tetrapropenylsuccinic anhydride (CAS #26544-38-7) to hydrolyze will be characterized in the testing program proposed by the HERTG panel, this data will be reviewed for applicability to the higher ASAs. If data is considered insufficient after these reviews, additional hydrolysis testing will be considered for the higher ASAs.

•**Photodegradation** -The chemical structure of higher ASA category members will be evaluated to determine whether there is a potential for direct photodegradation. Data will also be developed to characterize indirect photodegradation for category members using the AOP model in EPIWIN (version 3.12). Information or data for both routes of degradation will be provided in robust summaries after developed.

•**Fugacity modeling**: Environmental partitioning data for members of this category will be calculated using a Mackay Level III equilibrium partitioning model and provided in robust summaries after developed.

•**Acute fish toxicity –** Test data will be provided for C1618 ASA to bridge to other members of the category.

•**Acute invertebrate toxicity**. Test data will be provided for C1618 ASA to bridge to other members of the category.

•**Mutagenicity** Bacterial mutagenicity (Ames) and Unscheduled DNA Synthesis (UDS) test results will be provided for C1618 ASA to bridge to other members of the category.

Repeated-dose toxicity - The ACC HERTG group proposed testing of tetrapropenyl butanedioic acid (CAS #27859-58-1) in a 28-day dose-range finding study for the reproductive/developmental toxicity study. This information will be reviewed when available, and need for further testing for the higher ASA category will be considered. Unnecessary animal testing will be avoided if possible.

•**Reproductive/developmental toxicity –** The ACC HERTG group proposed testing of tetrapropenyl butanedioic acid (CAS #27859-58-1) in a one-generation reproduction toxicity study. As careful consideration was given to the number of animals that would be required for tests included in the HERTG plan , and in consideration of the concerns of some non-governmental organizations about animal welfare, this testing will be reviewed when available to consider the need for further testing of this endpoint for the higher ASA category.

TABLE OF CONTENTS

1.0 INTRODUCTION

This test plan sets forth how Albemarle Corporation intends to address physico-chemical, environmental, aquatic and health effects testing information for the following three substances to extend the Alkenyl Succinic Anhydride category to "Higher ASAs". These added ASAs have longer alkenyl chain length substituents and are used primarily as sizing in the production of alkaline paper. They are:

2,5-Furandione,3-(hexadecenyl)dihydro-, (CAS #32072-96-1), referred to as "hexadecenylsuccinic anhydride" or "C16 ASA" (an HPV chemical).

2,5-Furandione,3-(octadecenyl)dihydro-, (CAS #28777-98-2), referred to as "octadecenylsuccinic anhydride" or "C18 ASA" (an HPV chemical)

2,5-Furandione,3-(eicosenyl)dihydro-, (CAS #53520-67-5), referred to as "eiconsenylsuccinic anhydride" or "C20 ASA" (an Extended HPV chemical)

These chemicals extend the ASA category proposed by the ACC HERTG panel for:

•2,5-Furandione,dihydro-3-(tetrapropenyl)-,(CAS #26544-38-7), referred to as "tetrapropenylsuccinic anhydride".

•Butanedioic acid,(tetrapropenyl)-, (CAS #27859-58-1), referred to as "tetrapropenyl butanedioic acid".

•2,5-Furandione,3-(dodecenyl) dihydro-,(CAS #25377-73-5), referred to as "dodecenylsuccinic anhydride" or "C12 ASA" or "DDSA".

In the ACC HERTG test plan, CAS #25377-73-5 and CAS #26544-38-7 are considered interchangeable and refer to the same substance, a C12 alkenyl succinic anhydride. Because under many conditions the diacid form of the anhydride will be the form that exists and drives concern, consideration of both is necessary to adequately assess hazard for this category. For this reason, the anhydride and diacid were included together in the ACCHERTG test plan.

EPA guidance on the HPV Chemical Challenge Program indicates that the primary purpose of the program is to encourage "the chemical industry to voluntarily compile a Screening Information Data Set (SIDS) on all chemicals on the US HPV list." ((EPA, "Development of Chemical Categories in the HPV Challenge Program," p..1) At the same time, EPA recognizes that the "large number of chemicals to be tested [about 2800 HPV chemicals] makes it important to reduce the number of tests to be conducted, *where this is scientifically justifiable.*" ((*Id.*,p.1) [emphasis added]

The next part of the guidance explains where this would be scientifically justifiable: One approach is to test closely related chemicals as a group, or category, rather than test them as individual chemicals. In the category approach, *not every chemical needs to be tested for every SIDS endpoint.* However, *the test data finally compiled* for the category must prove adequate to support a screening level hazard-assessment of the category and its members. That is, the *final data set* must allow one to estimate the hazard for the untested endpoints, *ideally* by interpolation between and among the category members. In certain cases, where toxicity is low and no upward trend is expected, extrapolation to the higher category members may be acceptable. (*Id.*,p.1) [emphasis added]. EPA guidance goes on to state, "The use of categories is encouraged in the Challenge Program and will have a number of benefits." (*Id.*, p.1). Among the benefits identified in the guidance for the use of categories are "a reduction in testing will result in fewer animals used to test a category of chemicals as opposed to doing each test on each individual chemical," and "there will be economic savings since less testing may be needed for chemicals considered as a category." ((*Id.*,p.1). That guidance also states that categories "accomplish the goal of the Challenge Program – to obtain screening level hazard information – through the strategic application of testing to the category." ((*Id* ,p.2)

A similarly stated intent "to reduce the number of tests to be conducted, *where this is scientifically justifiable* " was presented by the Agency in its draft guidance document "The Use of Structure Activity Relationships (SAR) in the High Production Volume Chemicals Challenge Program.". The EPA "Chemical Categories" guidance defines what constitutes a "chemical category, for the purposes of the Challenge Program ". Specifically, that definition states that a chemical category under the HPV Challenge Program "is a group of chemicals whose physicochemical and toxicological properties *are likely to* be similar *or* follow a regular pattern as a result of structural similarity." ((*Op.Cit* .,p.2)[emphasis added].

The guidance states that the important point is that "structural similarities [among members of the group] *may* create a predictable pattern *in any* or all of the following parameters: physicochemical properties, environmental fate and effects, and human health effects." ((Id.,p.2) [emphasis added]. Chemicals in a category do not have to be similar in all respects. There also does not have to be conclusive proof that the chemicals in the proposed category will behave identically across all relevant parameters. For an "acceptable" category in the HPV Challenge Program there should be a *likelihood* of similarity of physicochemical and toxicological properties or a *likelihood* that the chemicals will in some appropriate fashion follow a regular pattern because of their structural similarity. The ACC HERTG panel, followed the six-step process set out in the EPA guidance on category development to develop the alkenyl succinic anhydride category. As the information below indicates, the alkenyl succinic anhydride chemicals, and the higher ASA chemicals meet the standards established in that guidance for use of a chemical category:

Step 1: group structurally similar chemicals into a proposed category

Step 2: gather relevant published and unpublished literature for each member of the category

Step 3: evaluate the compiled data for adequacy in accordance with the EPA guidance documentation

Step 4: construct matrices of SIDS endpoints versus category members arranged to demonstrate the structural progression of the category (by increasing molecular weight in the original ASA category, and for the higher ASAs, extension of the alkenyl chain length by 2 carbons)

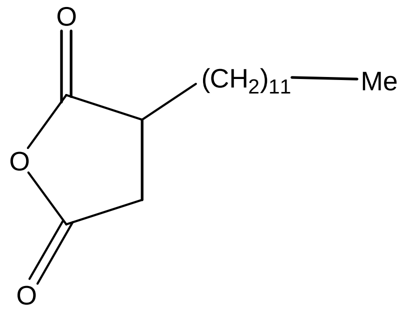
Step 5: evaluate the data to determine a correlation between category members for each SIDS endpoint

Step 6: make available the test plan for review including the category definition and rationale, the data assessment and the proposed testing scheme for the higher alkenyl succinic anhydrides in relationship to the original alkenyl succinic anhydride chemicals

2.0 CHEMISTRY OF ALKENYL SUCCINIC ANHYDRIDES

2.1 DESCRIPTION

The alkenyl succinic anhydrides presented in the initial category consisted of a tetrapropenyl moiety, a mono unsaturated branched hydrocarbon, and a succinic anhydride group. Dodecenyl succinic anhydride (DDSA) as described by CAS #25377-73-5 consists of a linear monounsaturated hydrocarbon and a succinic anhydride group. A general structure for DDSA is shown below as

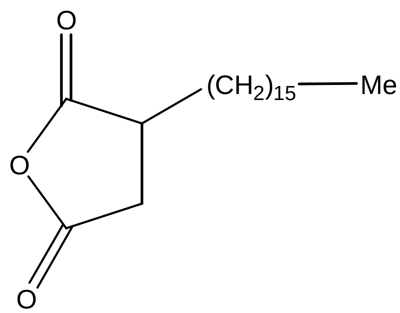


Dodecenyl succinic Anhydride

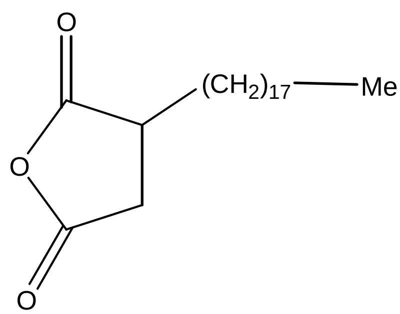
The location of the double bond in the alkenyl chain, when alpha olefins are used as raw materials, will be moved one carbon from where the chain attaches to the anhydride ring.

The alkenyl succinic anhydrides of higher molecular weight for this category also consist of monounsaturated linear hydrocarbons and a succinic anhydride group. The higher ASAs differ in length of the alkyl substituent, differing by two carbon length as the starting material for the olefins are ethylene based, not propenyl as are the branched members of the original category proposed by the ACC HERTG.

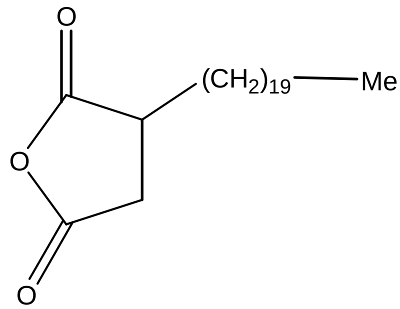
Structures of ASAs and C16, C18, C20 ASAs



Hexadecenyl Succinic Anhydride



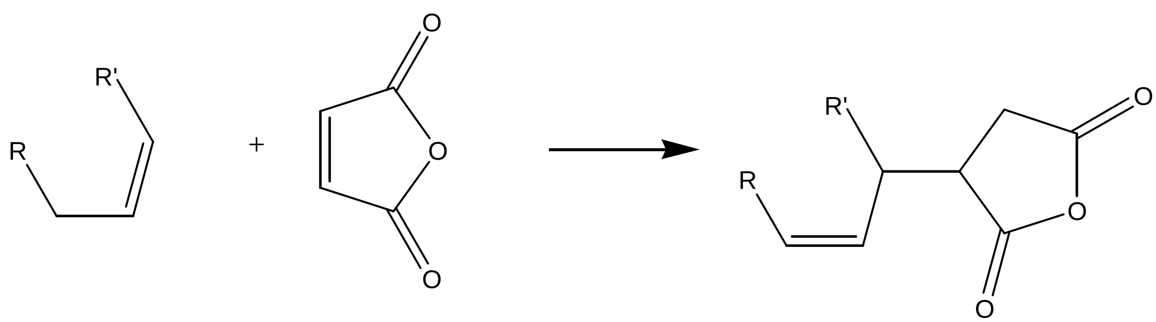
Octadecenyl Succinic Anhydride



Eicosenyl Succinic Anhydride

The second member of the category proposed by the HERTG is the diacid (CAS #27859-58-1) of the anhydride structure. The chemical names, simplified names, CAS numbers, and structures for the members of the alkenyl succinic anhydride category are presented in Tables 1 and 2.

Manufacture: The higher alkenyl succinic anhydrides are produced from a reaction of isomerized alpha olefins and maleic anhydride. The generic reaction is illustrated below:



C1618 ASA is prepared as follows: (C16 ASA and C18 ASA are prepared in an analogous manner, differing only in the final degree of separation)

A mixture of C16 and C18 alpha olefins is isomerized in order to move the nonsaturation (i.e. the double-bond site) from the alpha position to an internal position, with random distribution. The isomerization step is typically provided by the olefin supplier, but may be carried out by the ASA producer as well. The C1618 internal olefin is reacted with maleic anhydride, typically above 200’C, to form alkenylsuccinic anhydride.

Residual maleic anhydride and residual olefin are removed by a stripping step; afterwards, there is no detectable maleic anhydride and nominally 2% residual olefin. Care is taken throughout preparation and storage to limit exposure to moisture, to avoid slow hydrolysis of the maleic or succinic ring. (Hydrolysis of this ring would result in a diacid molecule, which is useless as a paper-sizing moiety. The product is analyzed to confirm that the hydrolyzate is kept below an acceptable level.)

2.2 PHYSICOCHEMICAL PROPERTIES

Selected physicochemical properties of members from the alkenyl succinic anhydride category and higher ASAs are presented in Table 3.

2.2.1 Molecular Weight

Members of the category have molecular weights of 266.4 to 378.6 daltons (Table 3).

2.2.2 Specific Gravity

The specific gravity of category members is approximately 1.0 g/ml (@25 °C) (Table 3).

2.2.3 Melting Point and Boiling Point

Alkenyl succinic anhydride and the diacid, as manufactured, are liquid at most ambient temperatures. Modeling data indicate that the melting point of these substances can range from approximately 14^{o}C to 40^{o}C for the anhydrides and 151^{o}C for the diacid (Table 3). Modeling data indicate that the melting point for the higher alkenyl chained ASA's range from 104.2^{o}C to 140.3^{o}C. Modeling data indicate that the boiling point of these substances can range from approximately 334^{o}C to 449^{o}C for the anhydrides and 409°C for the diacid. Modeling data for boiling point of the higher alkenyl chained ASA's range from 398.3° C to 444.8° C (Table 3).

2.2.4 Vapor Pressure and Viscosity

The low volatility of category members can be associated with their low vapor pressure, and high viscosity. Modeling data indicate that the vapor pressure of the members in category are equal to or less than 2.25E-6 mmHg @25^{o}C (see Table 3). The viscosity of dodecenylsuccinic anhydride (CAS #25377-73-5) is measured as 200 cSt @25 °C. This is the same as the measured value for C16 ASA. The viscosity of C18 ASA is 225 cSt (Table 3).

2.2.5 Water Solubility

The alkenylsuccinic anhydrides hydrolyze to alkenyl butanedioic acids in aqueous solution. The water solubility of the tetrapropenyl butanedioic acid (CAS#27859-58-1) was calculated by the ACC HERTG to be 3.2 mg/L (see Table 3). This value indicates that the diacid of the anhydride members of this category are sparingly soluble in water. The ACC HERTG proposed to confirm this value by developing measured water solubility data for this substance. Water solubility is reported as 5.33 x 10-5 mg/L for C18 ASA. (Syracuse Research Corporation Database). Modeling of water solubility of the higher alkenyl chain length ASA's show values less than 6.3×10^{-4} mg/L.

2.2.6 Octanol-Water Partition Coefficient

The log octanol-water partition coefficient (Kow) value of the tetrapropenyl butanedioic acid (CAS #27859-58-1) was calculated by the ACC HERTG to be 4.8 (see Table 3). Kow values for the anhydrides in the original category were not provided because panel believed these substances would not be present in their anhydride forms in the aqueous phase. Kow reported for C18 ASA is 9.44 estimated (Syracuse Research Corporation Database). Modeling values for log Kow for the higher alkenyl chain length ASAs range from 8.38 to 10.34, but these materials, like those in the original category, would also form diacid materials in water.

3.0 USES OF THE ALKENYL SUCCINIC ANHYDRIDE CATEGORY

The alkenyl succinic anhydrides reported in the ACC HERTG category are used as intermediates used in the synthesis of corrosion inhibitor components in lubricants (e.g., motor oils, metalworking oils, industrial oils) by the petroleum additive industry. Other non-petroleum additive applications of alkenyl succinic anhydrides include the following: a) intermediates in the production of surfactants, b) epoxy curing agents, c) leather tanning agents, and d) paper sizing agents.

The major use for the higher ASA products (such as C1618 ASA) is as an alkaline internal sizing agent for paper. Sizing agents reduce the paper's tendency to be penetrated by water, dyes, and inks. The contact angle of liquid with the surface is modified. This results in decreased water absorption and improved print quality. For writing paper, the benefits include reduced feathering, blurring, and bleed. For copying, the benefits include quick setting and good adhesion of toner. For printing, the benefits include reduced smearing and bleed, good color density, and good black density.

ASA is typically supplied to paper manufacturers containing about 1% of a non-aqueous surfactant. At the paper mill it is emulsified into a mixture of water plus cationic starch (or alternately, cationic polymer) and retention aid. This emulsion is, in turn, blended with the paper pulp. The pulp mixture is applied to the machine, which forms, presses and dries the paper into a finished roll. During this process, the succinic anhydride moiety reacts with hydroxyl moieties on cellulose, opening the ring structure. One end of the opened ring forms a C-O-C bond with cellulose, the other end terminates as COOH. Virtually all of the sizing effect between the ASA and the paper is developed on the paper machine.

Shipping of materials for paper sizing can include drums, or can be bulk shipped. Classification of higher ASAs for bulk transport on ships is Pollution Category "D" by GESAMP.

The ACC HERTG panel discussed the alkenyl succinic anhydride applications that involved blending into additive packages. Those ASAs are generally sold to finished oil blenders in additive packages, where the concentration ranges from 0.12 to 1.0 wt-%. The additive packages are then blended into finished products where the typical concentration of alkenyl succinic anhydrides ranges from 0.1 to 1.0 ppm. Additive packages are shipped to customers in bulk using ships, isocontainers, railroad tank cars, tank trucks, or 55-gallon steel drums. The anhydride products are carefully protected from moisture during transportation and storage to avoid hydrolysis to the diacid. Bulk additive packages are stored in bulk storage tanks at the customer blending sites. Finished oils are blended by pumping the lubricating oil blend stocks and the additive package from their storage tanks through computer controlled valves that meter the precise delivery of the components into a blending tank. After blending, the finished lubricant products are sold in bulk and shipped in tank trucks to large industrial users, such as manufacturing facilities and facilities that service truck fleets and passenger motor vehicles. Finished lubricants are also packaged into 55-gallon drums, 5-gallon pails, and one-gallon and one-quart containers for sale to smaller industrial users. Sales of lubricants in one-gallon and one-quart containers to consumers at service stations or retail specialty stores also occur.

Based on these uses, the potentially exposed populations include (1) workers involved in the manufacture of alkenyl succinic anhydrides, synthesis of components, the blending of additive packages, and blending the additive packages into finished lubricants; (2) quality assurance workers who sample and analyze these products to ensure that they meet specifications; (3) workers involved in the transfer and transport of alkenyl succinic anhydrides, additive packages or finished lubricants that contain them; (4) mechanics who may come into contact with both fresh and used lubricants while working on engines or equipment; (5) gasoline station attendants and consumers who may periodically add lubricating oil to automotive crankcases; and (6) consumers who may change their own automotive engine oil.

The most likely route of exposure for these substances in all applications (additive or paper sizing) is skin and eye contact. Manufacturing, quality assurance, and transportation workers will likely have access to engineering controls and wear protective clothing to eliminate exposure. The most likely source of environmental exposure is accidental spills at manufacturing sites and during transport.

4.0 EVALUATION OF AVAILABLE PUBLIC AND COMPANY DATA

4.1 ENVIRONMENTAL FATE DATA

4.1.1 Physicochemical Properties Relevant to Environmental Fate

In order to evaluate the environmental fate of a substance, it is important to understand its potential degradability and partitioning behavior among environmental compartments (i.e. air, soil, sediment, suspended sediment, water and biota

4.1.2 Biodegradation

4.1.2.1 Test Methodologies

The potential biodegradability of a substance in water, under aerobic conditions can be assessed using one of the OECD 301 testing guidelines. Chemical biodegradation involves a series of microbial-mediated reactions that can require many kinds of microorganisms acting together to degrade the parent substance. There are several standard test methods, which measure primary degradation (i.e. loss of parent chemical) or ultimate degradation (i.e. complete utilization of the substance to produce carbon dioxide, water, mineral salts, and microbial biomass). Primary degradation can be determined analytically by measuring dissolved organic carbon (DOC) for water-soluble chemicals, infrared absorbance, or by a chemical-specific detection method. Ultimate degradation (also called mineralization) can be determined by measuring oxygen consumption or carbon dioxide evolution relative to the theoretical levels that can be achieved based on an elemental analysis of the chemical under investigation.

4.1.2.2 Summary of Available Data

Biodegradation data for the alkenyl succinic anhydride category are summarized in Table 4.

Since dodecenylsuccinic anhydride and tetrapropenylsuccinic anhydride hydrolyze to their alkenyl butanedioic acids, using the biodegradability of the diacid to assess the biodegradability of the anhydrides is appropriate. Tetrapropenyl butanedioic acid (CAS #27859-58-1) was evaluated using the Manometric Respirometry Test (OECD Guideline 301F). After 28-days, this substance exhibited 18.3% biodegradation, based on theoretical oxygen demand.

4.1.2.3 Data Assessment and Test Plan for Biodegradability

The ACC HERTG panel found adequate biodegradation data existed for tetrapropenyl butanedioic acid (CAS #27859-58-1). Since the alkyl side chains of substances in this category are predominantly branched, the results indicate that these substances would exhibit limited biodegradation under the conditions of the test system. These results will be used to bridge to all category members. Modeling of biodegradation of the higher chain length ASAs indicates that biodegradation could be rapid.

4.1.3 Hydrolysis

4.1.3.1 Test Methodologies

When an organic molecule undergoes hydrolysis, a nucleophile (water or hydroxide ion) attacks an electrophile and displaces a leaving group (e.g., halogen, phenoxide). Potentially hydrolyzable groups include alkyl halides, amides, carbamates, carboxylic acid esters and lactones, epoxides, phosphate esters, and sulfonic acid esters, as well as anhydrides. Otherwise, the lack of a suitable leaving group renders compounds resistant to hydrolysis.

4.1.3.2 Summary of Available Data

There are no published or unpublished hydrolysis studies for members of this category.

4.1.3.3 Data Assessment and Test Plan for Hydrolysis

Tetrapropenylsuccinic anhydride contains a functional group that has the potential to hydrolyze. Alkenyl butanedioic acid is the hydrolysis product of this anhydride. This reaction is believed to occur at a rapid rate. The ACC HERTG proposed to review the public and private literature will be reviewed to determine if sufficient information was available to assess the potential hydrolysis rate of the alkenyl succinic anhydride. In the event that insufficient information was available, the ACC HERTG would test for hydrolysis rate of tetrapropenyl butanedioic acid (CAS #27859-58-1). These data, when available will be reviewed for application to the higher ASAs.

4.1.4 Photodegradation

4.1.4.1 Testing and Modeling Methodologies

Photodegradation can occur as a result of direct and indirect mechanisms. Direct photodegradation can be measured in solution using the OECD test guideline 113, while indirect photodegradation can be estimated using a model accepted by the US EPA. Simple chemical structures can also be examined to determine whether a chemical has the potential for direct photolysis in water.

4.1.4.2 Summary of Available Data

Published or unpublished photodegradation studies and AOP data for members of the alkenyl succinic anhydride category and higher ASAs are not available.

4.1.4.3 Data Assessment and Test Plan for Photodegradation

An initial review of the members of the alkenyl succinic anhydride category and the higher ASAs suggests that the members do not contain bonds that have a high potential to absorb UV light above 290 nm. These substances also have low vapor pressure, reducing their potential to partition significantly into the air where they would be subject to indirect photodegradation. To develop adequate data for this endpoint, the UV light absorptive potential of chemicals in this category will be evaluated to identify those chemicals with a potential to degrade in solution. When possible, first order reaction rates will be calculated for chemicals identified to have a potential for direct photolysis in water. The results of the calculations will be summarized in a technical discussion in the form of a robust summary. If instead, a low potential for direct photolysis is suggested by the evaluation, a technical discussion will be prepared as a robust summary describing the findings.

The AOP data for representative structures of the category (Table 2) will be estimated and the following data provided in a robust summary: Rate constants for the atmospheric, gas phase reactions as mediated by photochemically produced hydroxyl radicals, atmospheric half-lives based on hydroxyl radical attack.

4.1.5 Fugacity Modeling

4.1.5.1 Modeling Methodologies

Fugacity-based multimedia fate modeling calculates the relative distribution of a chemical between environmental compartments. A widely used model for this approach is the EQC model .

4.1.5.2 Summary of Available Data

There are no published or unpublished fugacity-based multimedia fate modeling data for members of the alkenyl succinic anhydride category or higher ASAs. All of the members of this category have low vapor pressure and sparingly low water solubility suggesting that they will not tend to partition into the air or water to any great extent.

4.1.5.3 Test Plan for Fugacity

The relative distribution of substances within this category among environmental compartments will be evaluated using the Level III model.

Because of the physical nature of the substances in this category, a Level III data set will be used to assess the potential partitioning behavior of the category members in the environment. The model used by the ACC HERTG was EPIWIN, version 3.04 (EPIWIN, 1999, Estimation Program Interface for Windows, version 3.04, Syracuse Research Corporation, Syracuse, NY, USA for the ACC HERTG panel). For the Higher ASAs, version 3.12 will be used. EPIWIN includes algorithms for estimating all physical and chemical properties needed for the EQC model. The representative structures that will be used are listed in Table 2.

4.2. ECOTOXICOLOGY DATA

4.2.1 Aquatic Ecotoxicity Testing

4.2.1.1 Test Methodologies

Acute aquatic ecotoxicity testing usually include three species, representing three tropic levels, in the freshwater aquatic environment: fish, invertebrates, and algae. The fish acute toxicity test (OECD Guideline 203, *Fish, Acute Toxicity Test*) determines the lethality of a substance to a fish during a 96-hour exposure period. The invertebrate acute toxicity test (OECD Guideline 202, *Daphnia sp. Acute Immobilization Test and Reproduction Test*) determines the potential of a substance to immobilize an invertebrate, typically a daphnid (*Daphnia magna*), during a 48-hour exposure period. The alga growth inhibition test (OECD Guideline 201, *Alga Growth Inhibition Test*) determines the potential of a substance to inhibit alga growth, typically using the freshwater unicellular green algae, *Pseudokirchneriella subcapitata* (formerly called *Selenastrum capricornutum*), during a 72-or 96-hour exposure period. In some cases, the saltwater aquatic environment, rather than freshwater, is the water system of concern, such as for consideration of the aquatic hazards of chemicals shipped over oceans. In those cases, saltwater species of fish, invertebrates and algae can be used.

Three different exposure methodologies are available to conduct aquatic toxicity tests; flow-through, static, and static renewal of the medium containing test article. In *flow-*

through exposures, organisms are exposed to a constant chemical concentration or loading in each treatment level in the incoming water and there is typically greater assurance than with other test methods that the exposure levels and water quality remains constant throughout the test. Although flow-through testing is the preferred method, it is most applicable for chemicals that have adequate water solubility for testing. In *static exposures,* organisms are exposed to a chemical in a test medium that is not replaced for the duration of the study. There is less assurance that the test concentrations or loadings to which test organisms are exposed will remain constant because test substance can be adsorbed onto test chambers, degraded, volatilized, or otherwise changed during the test.

However, due to limitations of other test systems for non-volatile substances, the static test has been widely used and in some instances must be used, such as for conducting an alga test.

The *static-renewal exposure* is similar to a static exposure because it is conducted in still water, but the test solutions and control water are renewed periodically, usually every 24 hours. Daily test solution renewal provides a greater likelihood that the exposure concentrations or loadings will remain stable throughout the test. Daily renewals cannot be performed in the alga test because the process of exposure solution separation and replenishment can cause a discontinuity in the alga growth rate. Also, dependent on the substance and test procedure used, renewals may not be possible for the *Daphnia* test because the procedure can stress *Daphnia* or result in coating or entrapping the organisms in surface film that may form during renewal operations. OECD considers the use of static testing for fish, *Daphnia* ,and algae, and the use of static renewal testing for fish to be appropriate when evaluating the toxicity of sparingly water-soluble substances like those in this category provided that test solution preparation uses water accommodated fraction or water soluble fraction methods. (Organization for Economic Cooperation and Development (OECD)(2000). Guidance Document on Aquatic Toxicity Testing of Difficult Substances and Mixtures. OECD Environmental Health and Safety Publications, Series on Testing and Assessment No.23, Paris, France.8 American Society for Testing and Materials (1998) D6081-98, Standard Practice for Aquatic Toxicity Testing of Lubricants: Sample Preparation and Results Interpretation).

4.2.1.2 Test Solution Preparation

Alkenyl succinic anhydrides are sparingly soluble to insoluble in water, and it is not possible to prepare exposure solutions for aquatic toxicity testing by direct addition of measured quantities of test material to water. Two methods are used to prepare solutions of poorly water-soluble materials for aquatic toxicity testing:

Water accommodated fraction (WAF)– This is a method in which the test solution contains only that fraction of the test material (organic phase) which is retained in the aqueous phase after a period of stirring long enough to reach equilibrium, followed by a sufficient time (1-4 hours) for phase separation. The WAF (aqueous phase) will contain soluble components of the test material at levels that will be dependent on the test material loading (the amount of material added to the aqueous medium). The resulting

WAF is used in the aquatic toxicity test. Ideally, a WAF consists of a water-soluble extract of test material, but it can also include a stable micro-emulsion or contain small amounts of suspended matter.

Water soluble fraction (WSF)– This is a method in which a WAF is either filtered, centrifuged, or allowed to settle for a greater length of time (24 hours) than with the WAF method to remove suspended matter from the aqueous phase before being used in the aquatic toxicity test.

4.2.1.3 Reporting Toxicity Results

In both WAF and WSF tests, material concentrations are expressed as loading rates; i.e., defined as the weight of test material added per unit volume of test medium during WAF or WSF preparation (Organization for Economic Cooperation and Development, 1999, Draft Guidance document on Aquatic Toxicity Testing of Difficult Substances, France). For fish tests, endpoints can be expressed as median lethal loading rate (LL50) when lethal effects occur to 50%of the test population or in cases where no lethal effects are observed at all loadings tested, LL0. In both cases, results can be expressed in mg/L and in studies where no lethality is observed, the result is expressed as LL0 =the highest loading rate tested. For invertebrate and alga tests, endpoints are expressed as median effective loading rate (EL50) or EL0 in mg/L as discussed above. Loading rates allow sparingly water-soluble to insoluble complex substances such as the alkenyl succinic anhydrides to be compared to more readily soluble substances and/or pure chemicals on an equal basis. To allow comparison, the toxicity value is expressed as the amount of test material added per unit volume of water when preparing the WAF or WSF. If test material exposure levels are analytically measured in the test, the endpoints can also be expressed as median lethal concentration (LC50)or median effective concentration (EC50) in mg/L. EC/LC50s are often not reported because it is very difficult to accurately measure test material exposure levels that can be below 1.0 mg/L.

NOTE: In the ACC HERTG test plan, the results are reported as loading rates (EL/LL), to reflect the current reporting practices for the WAF method used in the tests. In the robust summaries, these data are presented as concentrations (EC/LC) as originally reported even though the test methods employed WAF preparation of test solutions without measurement of test material concentration.

4.2.2 Aquatic Toxicity of Members from the Alkenyl Succinic Anhydride Category

Preliminary modeling information indicates that members of the alkenyl succinic anhydride category have sparingly low water solubility. This assessment is based on the diacid form of the anhydrides. The diacid form is used because aquatic organisms will only be exposed to the diacid, which is the hydrolyzed form of the anhydride. The length of the alkenyl side chain on these substances will influence their relative water solubility and thus possibly, their relative toxicity.

4.2.2.1 Summary of Available Data

Acute aquatic ecotoxicity data for the alkenyl succinic anhydride category is summarized in Table 5. One member of the original category (i.e., tetrapropenyl butanedioic acid) was tested for effects on algal growth. For the higher ASAs, C1618 ASA has been tested in salt water mysid shrimp (*Mysidopsis bahia*) and saltwater fish (Sheepshead minnow, *Cyprinodon variegatus*).

4.2.2.1.1 Alga Toxicity

The ACC HERTG reported that Tetrapropenyl butanedioic acid (CAS #27859-58-1) was evaluated for effects on the growth of the unicellular green alga, *Pseudokirchneriella subcapitata* , in a 96-hour exposure. The test substance loading rate were from 0.3 to 3,000 mg/L. The test substance was considered algistatic to freshwater alga, at loading rates of 330 and 3000 mg/L. The EC50 for this substance was 93 mg/L.

4.2.2.1.2 Invertebrate Toxicity

C1618 ASA was tested for effects on the saltwater mysid (Mysidopsis bahia) in a 96 hour static renewal test. The LC50 value was approximately 169 mg ASA/L.

4.2.2.1.3 Fish Toxicity

C1618 ASA was tested for effects on the saltwater fish (sheepshead minnow, *Cyprinodon variegates*) in a 96 hour static renewal test. The LC50 value was approximately 1000 mg ASA/L.

4.2.2.2 Data Assessment and Test Plan for Aquatic Toxicity

The ACC HERTG proposed to test tetrapropenyl butanedioic acid (CAS #27859-58-1) for aquatic toxicity to represent the C12 ASAs in the original category. Tests proposed included fish and invertebrate species. Data from the ACC HERTG test plan plus the fish and invertebrate testing of C1618 ASA should be sufficient to characterize the alkenyl succinic anhydrides and the higher ASAs.

4.3 MAMMALIAN TOXICOLOGY DATA

4.4

4.3.1 Physicochemical Properties Relevant to Mammalian Toxicity

Physicochemical properties of chemicals are useful for predicting the routes by which exposure may occur, and in some cases, the mechanism and extent of toxicological responses. The physicochemical properties of the alkenyl succinic anhydride are presented in Table 3. These lubricant additive intermediates are liquid substances with low octanol/water partition coefficients and sparingly water solubilities. These characteristics indicate that alkenyl succinic anhydrides are slightly lipophilic, and thus, capable of passive diffusion across biological membranes. It would be predicted that upon oral exposure these chemical substances would be absorbed by the gastrointestinal tract. However, the structural and physical properties such as comparatively high molecular weight, the presence of long-chain tetrapropenyl moieties and sparingly water solubility, is expected to impede the rate and extent of absorption of alkenyl succinic anhydride from dermal surfaces. In addition to the general considerations discussed above, the alkenyl succinic anhydrides have relatively high boiling points, low vapor pressure, and are viscous liquids. As a result, these substances have a low propensity to form vapors or aerosols, and thus, unintentional exposure via inhalation is uncommon.

4.3.2 Acute Mammalian Toxicity of Members from the Alkenyl Succinic Anhydride Category

4.3.2.1 Acute Toxicity Test Methodology Acute toxicity studies investigate the effect(s)of a single exposure to a relatively high dose of a substance. Potential routes of exposure for acute toxicity assays include oral, dermal, and inhalation. Oral toxicity assays are conducted by administering test material to fasted animals (typically rats or mice) in a single gavage dose. Acute dermal toxicity tests are conducted by administering test material to the shaved skin on the back of the test animal (typically rats or rabbits) and allowing the test material to stay in contact with the skin application site for a specific duration (usually 24 hours). Acute inhalation toxicity assays are conducted by exposing test animals (typically rats) in a controlled atmosphere to a fixed air concentration of the test substance for a specific duration (typically 4 hours). The test material is either generated as a vapor or intentionally aerosolized into respirable particles, then metered into the exposure air at the desired concentration. Preferably, inhalation toxicity studies are conducted using either nose-only or head-only exposure to minimize potential confounding effects resulting from whole-body exposure. Whole body exposure may lead to over- prediction of inhalation toxicity hazard by increasing the body-burden of the test material through skin absorption or ingestion of test material as a consequence of grooming both during and after the inhalation exposure period. Historically, lethality is a primary end-point of concern in acute toxicity studies, and the traditional index of oral and dermal potency is the median lethal dose that causes mortality in 50 percent of the test animals (LD50) .In acute inhalation studies, the traditional measurement of potency is the median lethal concentration of the test material in air that causes mortality in 50 percent of the test animals (LC50). In addition to lethality acute toxicity studies also provide insights regarding potential systemic toxicity through careful observation and recording of clinical signs and symptoms of toxicity as well as through detailed examination of tissues and organ systems. Typically, acute oral and dermal toxicity studies are conducted using a limit dose of 5000 and 2000 mg/kg body weight, respectively, and acute inhalation toxicity studies are conducted using a limit dose of 5 mg/L for 4 hours (according to OECD and EPA testing guidelines). Prior to 1990, some acute dermal toxicity studies may have used a limit dose of 5000 mg/kg. Recently, harmonized EPA testing guidelines (August 1998) have set the limit dose for both oral and dermal acute toxicity studies at 2000 mg/kg body weight, while the recommended limit concentration for acute inhalation studies has been set at 2 mg/L for 4 hours. The limit dose test method minimizes the number of animals tested by exposing a single group of animals to a large dose (the limit dose)of the test substance. A test substance that shows little or no effects at the limit dose is considered essentially nontoxic, and no further testing is needed. If compound-related mortality is observed at the limit dose, then further testing may be necessary.

4.3.2.2 Summary of Available Data

Acute toxicity data for the alkenyl succinic anhydride category is summarized in Table 6. The ACC HERTG reported that two of the three members of the original category were tested by the oral and dermal routes and had a low order of acute toxicity. C12 was reported tested for inhalation toxicity for 4 hour exposure. C1618 ASA has been tested for oral and dermal toxicity.

4.3.2.2.1 Acute Oral Toxicity

The ACC HERTG determined that two substances in the original alkenyl succinic anhydride category were adequately tested for acute oral toxicity. The acute oral LD50 for rats was greater than 2000 mg/kg, indicating a low order of acute toxicity. The acute oral LD_{50} for C1618 ASA is greater than 5000 mg/kg.

4.3.2.2.2 Acute Dermal Toxicity

The ACC HERTG determined that one substance in the original alkenyl succinic anhydride category had been adequately tested for acute dermal toxicity. The acute dermal LD50 for that chemical in rabbits was greater than 5000 mg/kg, indicating a low order of acute toxicity. Acute dermal LD_{50} for C1618 ASA is greater than 5000 mg/kg in rabbits, confirming low order of acute toxicity by the dermal route for the higher ASAs.

4.3.2.2.3 Acute Inhalation Toxicity

Dodecenylsuccinic anhydride (CAS #25377-73-5) has been adequately tested for acute inhalation toxicity (EPA/OTS Document No. 888100369, TSCA Sect. 8E, recorded 4/19/82, Buffalo Chemical Company, conducted by Food and Drug Research Laboratories). The acute inhalation LCLo for this study in rats was 1220 mg/m^3 for 4 hour exposure indicating a relatively low order of acute toxicity.

4.3.2.2.4 Irritation and Sensitization Potential.

Inadvertent worker exposure is possible in manufacturing and use of the ASAs and higher ASAs. Skin and eye irritation tests, as well as determination of the possibility of skin sensitization has been assessed in the lower and higher ASAs. The ASAs are potential skin sensitizers, and exposure to neat materials can irritate the skin and eyes.

4.3.2.3 Data Assessment and Test Plan for Acute Mammalian Toxicity

In total, three adequate acute toxicity studies have been conducted for two members of the original alkenyl succinic anhydride category, and confirmed in the data for the higher ASA group. These studies involved two species of laboratory animals (rats and rabbits) and three routes of exposure (oral and dermal, and inhalation), and evaluated the toxicity of two members of the original category, and the higher ASAs. Skin and eye irritation, and sensitization potential has been adequately tested also. The data consistently demonstrate a low order of acute toxicity. Based on the results of these studies, the acute toxicity of the category has been evaluated adequately, and no additional acute toxicity testing is proposed.

4.3.3 Mutagenicity of Members from the Alkenyl Succinic Anhydride

Category and Higher ASAs

4.3.3.1 Mutagenicity Test Methodology

Genetic toxicology is concerned with the effects of substances on genetic material (i.e., DNA and chromosomes).

4.3.3.2 Summary of Mutagenicity Data

A summary of the mutagenicity data for the alkenyl succinic anhydride category and Higher ASAs is presented in Table 7. Bacterial gene mutation tests (Ames test) and unscheduled DNA synthesis (UDS) tests have been conducted on C1618 ASA, representing the higher ASAs.

4.3.3.3 Data Assessment and Test Plan for Mutagenicity

Based on the propensity of anhydrides to hydrolyze under aqueous conditions, the tetrapropenyl butanedioic acid derivative (CAS #27859-58-1) was to be tested by the ACC HERTG panel and the data bridged to other members in category which lacks bacterial gene mutation and *in vitro* chromosomal aberration data for the HPV Challenge Program. C1618 ASA data will be used to bridge the higher ASAs, and after review of the data from the HERTG panel, need for further testing will be evaluated.

4.3.4 Repeated-dose Toxicity of Alkenyl Succinic Anhydride Category

4.3.4.1 Repeated-dose Toxicity Test Methodology

Repeated-dose toxicity studies evaluate the systemic effects of repeated exposure to a chemical over a significant period of the life span of an animal (rats, rabbits, mice or other mammals).

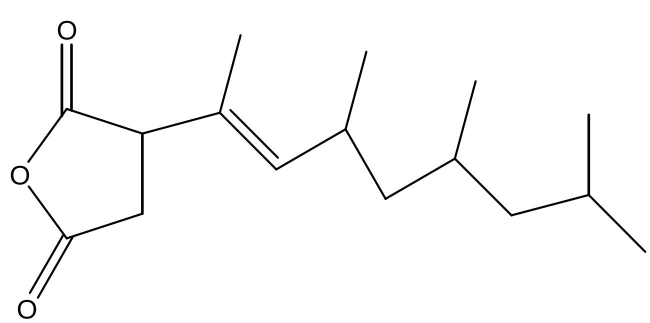
4.3.4.2 Summary of Repeated-Dose Toxicity Data

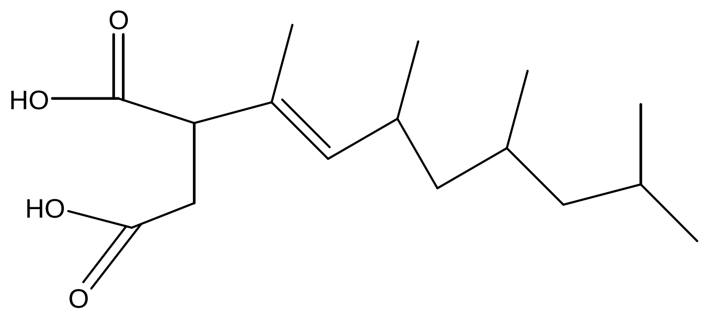
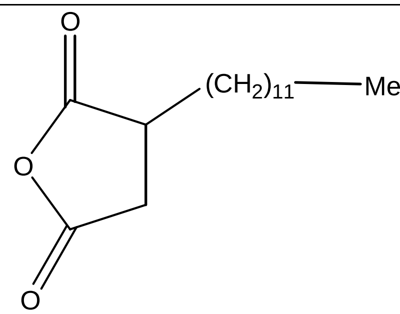
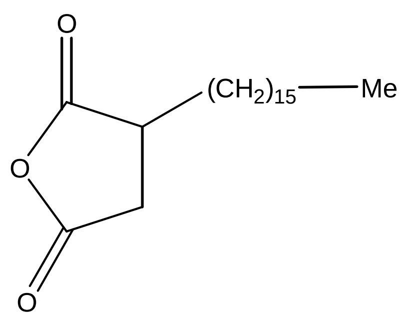
None of the members from the original alkenyl succinic anhydride category were tested for repeated-dose or reproductive and development toxicity. Based on the propensity of anhydrides to hydrolyze under aqueous conditions, the tetrapropenyl butanedioic acid derivative (CAS #27859-58-1) was to be tested by the ACC HERTG panel and the data bridged to other members in category which lacks repeated-dose toxicity and reproductive/developmental toxicity data for the HPV Challenge Program. The HERTG testing for repeated dose toxicity will be reviewed and the need for testing for higher ASAs will be considered.

TABLE 1. Members of the Alkenyl Succinic Anhydride Category

CAS Number	Chemical Name	Simplified Chemical Name
26544-38-7	2,5-Furandione,dihydro-3-(tetrapropenyl)-,derivatives	Tetrapropenylsuccinic anhydride
27859-58-1	Butanedioic acid, (tetrapropenyl)-, derivatives	Tetrapropenyl butanedioic acid
25377-73-5	2,5-Furandione,3-(dodecenyl) dihydro-, derivatives	Dodecenylsuccinic anhydride
32072-96-1	2,5-Furandione,3-(hexadecenyl) dihydro-, derivatives	Hexadecenylsuccinic anhydride
28777-98-2	2,5-Furandione,3-(octadecenyl) dihydro-, derivatives	Octadecenylsuccinic anhydride
53520-67-5	2,5-Furandione,3-(eicosenyl) dihydro-, derivatives	Eicosenylsuccinic anhydride
Mixture of 32072-96-1, 28777-98-2, 53520-67-5	Mixture of 2,5-Furandione,3-(hexadecenyl) dihydro-, Derivatives; 2,5-Furandione,3-(octadecenyl) dihydro-, Derivatives; and 2,5-Furandione,3-(eicosenyl) dihydro-, derivatives	C16C18 alkenylsuccinic anhydride

TABLE 2.Chemical Structures of Members of the Alkenyl Succinic Anhydride Category and Higher ASAs

CAS Number	Chemical Structure
26544-38-7	

27859-58-1	
25377-73-5	 Dodecenylsuccinic Anhydride
32072-96-1 Hexadecenyl Succinic Anhydride	 Hexadecenylsuccinic Anhydride
28777-98-2	

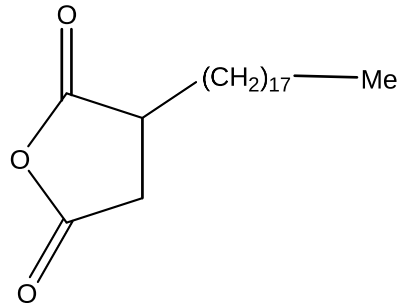
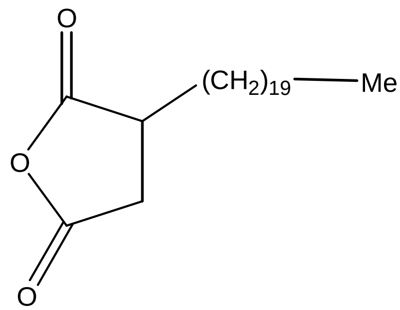
	 Octadecenylsuccinic Anhydride
53520-67-5	 Eicosenylsuccinic Anhydride

TABLE 3. Selected Physicochemical Properties and Proposed Testing for Members of the Alkenyl Succinic Anhydrides Category and Higher ASAs

CAS Number	Molecular Weight	Specific Gravity [1] (g/ ml)	Viscosity [2] (cSt @ 25 ^{o}C)	Melting Point [3] (^{o}C	Boiling Point [4] (^{o}C)	Vapor Pressure [5] (mmHg)	Water Solubility [6] (mg/ L)	Log Kow [6]
26544- 38- 7	266.4	1.005	ND	13.9	334.4	2.25E-6	NA 7	NA 8
27859- 58- 1	284.4	ND 12	ND	151.0	409.1	1.95E-9	Test (3.2, 9)	4.8
25377- 73- 5	266.4	1.002	200	40.3	348.8	7.5E-7	NA 10	NA 11

32072-96-1	322.5	0.955a	200	104.2[3]	235 a 398.3 [4]	1.54E-006 [5]	6.32×10^{-4}	8.38
28777-98-2	350.6	0.950a	225	65.3-69[s] 122.2[3]	258 a 421.5 [4]	3.4×10^{-1} at 25C s 2.68E-007 [5]	5.33×10^{-5} [s] 6.22×10^{-5}	9.44 est s 9.36
53520-67-5	378.6			140.3[3]	444.8 [4]	4.55E-008 [5]	6.09×10^{-6}	10.34
C16C18ASA		0.952a	205 a		250 a	< 1 at 20'C		

1 ASTM D1298- 99, Standard Test Method for Density, Relative Density (Specific Gravity) , or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
2 ASTM D 445- 97, Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (the Calculation of Dynamic Viscosity)
3 Modeling data; melting point is estimated (MPBWIN v1.40) and cannot be measured due to viscosity of liquid. Selected value from program chosen.
4 Modeling data; boiling point is estimated (MPBWIN v1.40) and cannot be measured because these substances decompose before they boil.
5 Modeling data; vapor pressure is estimated (MPBPWIN v1.40)
6 EPIWIN. 1999. Estimation Program Interface for Windows, version 3.04 and version 3.12, Syracuse Research Corporation, Syracuse, NY, USA.
7 Not applicable; anhydrides form diacids in aqueous solutions, see CAS # 27859- 58- 1 for water solubility of the diacid
8 Not applicable; anhydrides form diacids in aqueous solutions, see CAS # 27859- 58- 1 for the calculated Log Kow value of the diacid.
9 Modeling data; water solubility is estimated (KOWWIN v1.65) .
10 Not applicable; anhydrides form diacids in aqueous solutions, the water solubility of the diacid of CAS # 25377- 73- 5 is calculated to be 2.4 mg/ L.
11 Not applicable; anhydrides form diacids in aqueous solutions.
12 No data needed (ND) ; bridging from other members of the category.
a = Albemarle Corporation
s – Syracuse Research, SRC Physical Property Database

TABLE 4. Environmental Fate Data and Proposed Testing for Members of the Alkenyl Succinic Anhydrides Category and Higher ASAs

CAS Number	BIODEGRADATION	HYDROLYSIS	PHOTODEGRADATION	FUGACITY
	Available data and proposed testing	**Available data and proposed testing**	**Available data and proposed testing**	**Available data and proposed testing**
26544- 38- 7	No testing proposed Bridging	Technical Discussion	Direct photodegradation evaluation AOPWIN model estimation	EQC model estimation

27859- 58- 1	18.3% biodegraded after 28- days	Technical Discussion	Direct photodegradation evaluation AOPWIN model estimation	EQC model estimation
25377- 73- 5	No testing proposed Bridging	Technical Discussion	Direct photodegradation evaluation AOPWIN model estimation	EQC model estimation
32072-96-1	No testing proposed Bridging	Technical Discussion	Direct photodegradation evaluation AOPWIN model estimation	EQC model estimation
28777-98-2	No testing proposed Bridging	Technical Discussion	Direct photodegradation evaluation AOPWIN model estimation	EQC model estimation
53520-67-5	No testing proposed Bridging	Technical Discussion	Direct photodegradation evaluation AOPWIN model estimation	EQC model estimation

TABLE 5. Aquatic Toxicity Data and Proposed Testing for Members of the Alkenyl Succinic Anhydrides Category and Higher ASAs

CAS Number	ACUTE TOXICITY TO FISH 96- hr LC $_{50}$ (mg/ L)	ACUTE TOXICITY TO INVERTEBRATES 48- hr EC $_{50}$ (mg/ L)	TOXICITY TO ALGAE 96- hr EC $_{50}$ (mg/ L)
	Available Data & Proposed Testing	**Available Data & Proposed Testing**	**Available Data & Proposed Testing**
26544- 38- 7	No testing proposed Bridging	No testing proposed Bridging	No testing proposed Bridging
27859- 58- 1	Test	Test	Test EC $_{50}$ = 93 mg/ L (WAF, PK)
25377- 73- 5	No testing proposed Bridging	No testing proposed Bridging	No testing proposed Bridging
32072-96-1	No testing proposed Bridging	No testing proposed Bridging	No testing proposed Bridging
28777-98-2	No testing proposed Bridging	No testing proposed Bridging	No testing proposed Bridging
53520-67-5	No testing proposed Bridging	No testing proposed Bridging	No testing proposed Bridging
C16C18 mixture	Test EC 50 > 1000 mg/L (WSF, CP)	Test EC50 = 169 mg /L (WSF, MB)	No testing proposed Bridging

WAF = Water Accommodated Fraction
WSF = Water Soluble Fraction

PK = *Pseudokirchneriella subcapitata*
MB = *Mysidopsis bahia*
CP = *Cyprinodon Variegatus*

TABLE 6. Acute Mammalian Toxicity Data for Members of the Alkenyl Succinic Anhydride Category and Higher ASAs

CAS Number	ACUTE ORAL TOXICITY [1]	ACUTE DERMAL TOXICITY [1]
	Available Data	**Available Data**
26544- 38- 7	LD_{50} > 2.0 g/ kg (rat) [2]	LD_{50} > 5.0 g/ kg (rabbit) [2]
27859- 58- 1	No testing proposed bridging	No testing proposed bridging
25377- 73- 5	LD_{50} > 2.0 g/ kg (rat)	No testing proposed bridging
32072-96-1	No testing proposed bridging	No testing proposed bridging
28777-98-2	No testing proposed bridging	No testing proposed bridging
53520-67-5	No testing proposed bridging	No testing proposed bridging
C16C18 ASA	LD_{50} > 5.0 g/ kg (rat)[3]	LD_{50} > 5.0 g/ kg (rabbit) [3]

1 Toxicity endpoints are expressed as median lethal dose (LD 50) for acute oral and dermal toxicity **.**
2 R. J. Lewis (1998) . Sax' s Dangerous Properties of Industrial Materials, 9th Edition, John Wiley & Sons, Inc, New York, NY, USA
3 Testing by Ethyl Corporation

TABLE 7. Mutagenicity Data and Proposed Testing for Members of the Alkenyl Succinic Anhydride Category and ASAs

CAS Number	GENE MUTATION ASSAY	CHROMOSOMAL ABERRATION ASSAY
	Available Data & Proposed Testing	**Available Data & Proposed Testing**
26544- 38- 7	No testing proposed bridging	No testing proposed bridging
27859- 58- 1	Test	Test
25377- 73- 5	No testing proposed bridging	No testing proposed bridging
32072-96-1	No testing proposed bridging	No testing proposed bridging
28777-98-2	No testing proposed bridging	No testing proposed bridging
53520-67-5	No testing proposed bridging	No testing proposed bridging
C16C18 ASA	Ames Test Negative UDS Test Negative	

TABLE 8. Repeated- dose Mammalian Toxicity Data and Proposed Testing for Members of the Alkenyl Succinic Anhydride Category

CAS Number	Repeated Dose Toxicity	Reproductive/Developmental Toxicity
	Available Data & Proposed Testing	**Available Data & Proposed Testing**
26544- 38- 7	No testing proposed bridging	No testing proposed bridging
27859- 58- 1	Test	Test
25377- 73- 5	No testing proposed bridging	No testing proposed bridging
32072-96-1	No testing proposed bridging	No testing proposed bridging
28777-98-2	No testing proposed bridging	No testing proposed bridging
53520-67-5	No testing proposed bridging	No testing proposed bridging

TABLE 9: Assessment of Data and Test Plan

CAS Number	Environmental Fate					Ecotoxicity			Human Health Effects				
	Phys/ chem	Photo deg	Hydr olysis	Fugac ity	Bio deg	Acute Fish	Acute Invert	Alga tox	Acute Tox	Point muta tions	Chrom Effects	Subchro nic	Repro/ Develop
26544- 38- 7	C	D/C	D	C	B	B	B	B	A	B	B	B	B
27859- 58- 1	C/T	D/C	D	C	A	T	T	A	B	T	T	T	T
25377- 73- 5	C	D/C	BD	C	B	B	B	B	A	B	B	B	B
32072-96-1	C	D/C	BD	C	B	B	B	B	B	B	B	B	B
28777-98-2	C	D/C	BD	C	B	B	B	B	B	B	B	B	B
53520-67-5	C	D/C	BD	C	B	B	B	B	B	B	B	B	B
C16C18 mixture	NA	NA	NA	NA	NA	A	A	NA	A	A	NA	NA	NA

A Adequate data available
B Bridging data from another category member
C Computer modeling proposed
D Technical discussion proposed
T Test
NA Not Applicable, Mixture. Refer to individual components

ROBUST SUMMARIES: Higher Alkenyl Succinic Anhydrides

1.0 Biodegradation

Test Substance	CAS #27859-58-1
Chemical Name	Butanedioic acid, (tetrapropenyl)
Remarks	Test material purity not provided
Method Method/Guideline followed Test Type (aerobic/anaerobic)Aerobic GLP (Y/N) Contact time (units) Inoculum	 OECD 301F Manometric Respirometry Test (Biodegradation) Y 28 days Activated sludge from domestic wastewater treatment plant.
Year (Study Performed)	1999
Remarks for test conditions Test System Inoculum Concentration of test chemical (assay conducted in duplicate reactor flasks) Dosing procedure	 The test system was a defined mineral medium inoculated with the supernatant of homogenized activated return sludge from a public wastewater treatment plant. The mineral medium was prepared as outlined in OECD Guideline 301F The supernatant from homogenized activated sludge was used as inoculum. A two-liter flask containing 100 mL of supplemented sludge supernatant and 900 mL of test medium was prepared. The inoculum was pre-adapted to the test material for 14 days during which the test substance was added incrementally at concentrations equivalent to 4, 8, and 8 mg carbon/L on days 0, 7, and 11, respectively. The targeted microbial level in the test mixture was 10,000 to 1,000,000 cells/mL. The actual microbial level in the test mixture was 1000 cells/mL. This deviation from the protocol was not considered significant. Test substance concentrations were 107.2 and 110.2 mg/L, giving a 122.1 and 125.5 mg ThOD. No organic solvents were used to facilitate the dispersion of the test material. The test substance was weighed onto a Teflon coupon and introduced into the medium. Test mixtures were stirred throughout the study using magnetic stirrers. Temperature of incubation: 23 +1 ºC A measured volume of the inoculated mineral medium containing

	approximately 107-110 mg/L test substance was continuously stirred in a closed system for 28 days.
Sampling frequency	The oxygen uptake was monitored continuously and recorded every 4 hours throughout the test.
Controls	Yes (blank and positive controls per guideline); abiotic and toxicity checks were not included. Sodium benzoate was used as the positive control.
Analytical method	Oxygen uptake was measured using a BI-1000 electrolytic respirometer system. The hydrogen, nitrogen and total organic carbon content of the test material were determined.
Method of calculating measured concentrations	Material concentrations were not measured
Results Test Validity	All test validity criteria were met as follows: The average oxygen uptake of each of the two inoculum blanks was lower than 60 mg/L in 28 days. The difference in biodegradation levels of the reference and test substance replicates was less than 20%. The percent degradation of the reference material reached the pass level (60%) within 14 days. The final pH of the test mixtures were within the range of 6.0-8.5 demonstrating the biodegradation was not inhibited by extreme pH
Degradation: %after time	Test substance: 18.3% after 28 days Positive reference (sodium benzoate): =/>60% (3d)
Remarks Conclusion	18.3% after 28 days. The reference substance, sodium benzoate, reached a level of 94.2%in the same test period.

Data Quality (1) Reliable without restriction

References Unpublished Confidential Business Information taken from ACC HERTG panel Robust Summary “Alkenyl Succinic Anhydrides”, Update Nov. 22, 2002

Other

2.0 Ecotoxicity Category: Alkenyl Succinic Anhydride

AQUATIC ORGANISMS

2.3 Acute Toxicity to Aquatic Plants (e.g algae)

Test Substance	CAS #27859-58-1
Chemical Name	Butanedioic acid,(tetrapropenyl)-
Remarks	Test material purity not provided
Method Method /Guideline followed Test Type GLP (Y/N)	Test protocol followed US EPA Toxic Substances Control Act Test Guideline #797.1050 (1993), OECD Guideline for Testing of Chemicals #201 Alga, Growth Inhibition Test (1984). Static acute toxicity test Y
Year (Study Performed)	1996
Species/Strain	Freshwater algae**,** *Pseudokirchneriella subcapitata* formerly called *Selenastrum capricornutum*
Element basis (#of cells/mL)	Approximately 10,000 cells/mL
Exposure period/duration	96 hours
Analytical monitoring	No
Statistical methods	Average specific growth rate was calculated as the natural log of the number of cells/ml at 72 and 96 hours minus the natural log of the number of cells/ml at 0 hour, divided by the hour of exposure. Results were interpreted by standard statistical techniques. All calculations were performed using nominal concentrations of the test material with the number of cells/mL, then with the average specific growth rates.
Remarks field for test conditions (fill as applicable) Test Species Test System	 Cells taken from in-house culture *Pseudokirchneriella subcapitata* originally purchased from the University of Texas at Austin alga collection. Each WAF was prepared only at the beginning of the test. A measured weight of test material was added to a measured volume of dilution water in a glass vessel and stirred for 20 hours. Stirring accomplished using a magnetic stirrer. Mixing speed was adjusted such that a vortex formed approximately 25% of the distance to the bottom. Following the mixing period, the test solution was allowed to stand for 4 hour before the water phase was removed. The siphoned water phase (i.e. WAF) was used

	for the aquatic toxicity test.
Test Conditions Light Test temperature Dilution Water Test Levels Method of calculating mean measured concentrations	A static test was conducted; i.e. there was no daily renewal of test solution. Two 100-mL replicates per treatment, inoculum ~10,000 cells/mL. The 250-mL Erlenmeyer flasks were covered to reduce entry of dust. During the test all treatment and control flasks were randomly placed on an orbital shaker adjusted to approximately 100 cycles per minute under constant light (24 hours/day). The occurrence of relative size differences, unusual cell shapes, colors, flocculations, adherence of cells to test containers or aggregation of cells was determined visually by means of direct microscopic examination with a hemocytometer. Cell counts were made at 72 and 96 hours Cool-white fluorescent lights provided a light intensity of approximately 400-430 foot-candles. 24.0 C Sterile enriched alga growth media (US EPA, 1978) adjusted to pH 7.5. Measured total suspended solids in fresh untreated alga media were <10 mg/L, respectively. Test media pH was 7.4 at 0-hour and 10.2 after 96 hours. Control and 0.3, 3.0, 33, 330 and 3300 mg/L WAF loading rates. Insoluble material was observed at 24, 48 and 96 hours in test vessels containing 330 and 3300 mg/L. No other insoluble material was observed during the study not applicable
Exposure period	96 hours
Analytical monitoring	Not performed concentrations were all based on nominal.
Results Remarks Findings	96-h E_{C50} 93 mg/L; The 96-hr NOEC =33 mg/L. Insoluble material was observed at 24, 48 and 96 hours in test vessels containing 330 and 3300 mg/L; other insoluble material was observed during the study. The algal population grew well resulting in an average of 1,508,000 cells/mL in the control after 96 hours. Water quality was acceptable throughout the study. The two highest concentrations of test material significantly decreased the pH of the test media at the beginning of the test (330 mg/L pH: 4.3-4.4; 3000 mg/L pH: 3.9-4.0. No biological effects were noted during the study on cell size, shape, color, flocculation, adherence to test containers or aggregation.

	The 96-hour no observed effect concentration (NOEC) was 33 mg/L. The calculated EC50s were as follows: Based on Number of Cells/mL 72 hr EC50: 100 mg/L (95%confidence interval 33-330 mg/L) 96 hr EC50: 93 mg/L (95%confidence interval 33-330 mg/L) Based on Average Specific Growth Rate 72 hr EC50: 100 mg/L (95%confidence interval 33-330 mg/L) 96 hr EC50:100 mg/L (95%confidence interval 33-330 mg/L) •The toxic effects were determined to be algistatic based on the rapid re-growth of an aliquot of cells taken from the 330mg/L test vessel and cultured in fresh control media
Test Validity	Control response was satisfactory.
Conclusions	The test material was considered algistatic to freshwater alga at loading rates of 330 and 3000 mg/L. 96-h E_{C50} 93 mg/L; The 96-hr NOEC =33 mg/L.

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Data Quality (1) Reliable with restriction. Restriction due to the lack of any analytical confirmation of test material concentration in test solutions. All concentrations are expressed as nominal.

References Confidential business information, taken from ACC HERTG panel Robust Summary “Alkenyl Succinic Anhydrides”, Update Nov. 22, 2002

Other

2.4 Acute Aquatic Toxicity to Invertebrates

2.4.1 Acute Aquatic Toxicity to Invertebrates

Test Substance “C1618 ASA: alkenylsuccinic anhydride
CAS # Mixture: 32072-96-1, 28777-98-2, 53520-67-5
Chemical Name Mixture of hexadecenylsuccinic anhydride, octadecenylsuccinic anhydride, eicosenylsuccinic anhydride
Remarks: Purity: 99.82% active ingredient
Method
Method Guideline ASTM Standard E 729-88, “Standard Practice for Conducting

	Acute Toxicity Tests with Fishes, Macroinvertebrates, and Amphibians,
Test Type	Acute Aquatic Toxicity
GLP (Y/N)	Yes
Year	1991
Species/Strain	Saltwater mysid, *Mysidopsis bahia*
Exposure period/duration	96 hours
Analytical monitoring	Yes
Statistical methods	LC50 values and 95% confidence intervals were calculated using the computer program of C.E. Stephan. The program calculated the values using probit analysis, moving average-angle method or binomial probability with nonlinear interpolation. In this study, binomial method was used to evaluate mortality at 48 and 72 hours, and probit method used for 96 hours. The 24 hour LC50 was determined by visual inspection of the mortality data.

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Remarks field for test conditions (fill as applicable)

Test Species:	Mysids less than 24 hours old obtained from Wildlife International, Ltd. cultures. 20 organisms per test concentration.
Test System:	Each WAF was prepared daily by adding the appropriate amount of test substance to 4 L glass beakers, which were filled with 3 L of salt water, and stirred gently overnight with magnetic stirrers. After stirring, the solutions were allowed to settle for two hours and the water soluble fractions were siphoned from the middle of the beakers and delivered to the test chambers. Test chambers were 500 ml beakers with holes in two sides covered with Teflon screen. The beakers were placed in 2L beakers filled with 1 L of the prepared waters.
Test Conditions:	A static renewal test was conducted in that there was daily renewal of test solution. pH and dissolved oxygen content of the water in treatment and control aquaria were measured at 24 hour intervals before and after renewal.
Light:	Cool-white fluorescent lights provided a light intensity of approximately 60 foot-candles at water surface. Light cycle was controlled to 16 hours of light and 8 hours of darkness..
Test temperature:	Culture waters were 22.4’ to 25.0’ C. Tests were conducted at a target temperature of 25.1’C.
Dilution Water:	Natural seawater collected from Indian River Inlet, Delaware. Salt water was filtered through a sand filter and stored in a 37,800 L tank. Aeration using spray nozzles and filtration (0.2 um) removed organisms and particulates prior to introduction to test system.

	Salinity and pH of negative control water at beginning of test were 24 0/00 and 8.2 respectively.
Test Levels:	Negative Control and nominal concentrations of 8.1, 27, 90, 300 and 1000 mg/L WSF TOC measurements were made at the beginning and at 24 hour intervals to verify concentrations.
Method of calculating mean measured concentrations:	
Exposure period:	96 hours
Analytical monitoring:	Samples of 125 ml were analyzed by a TOC method. Total carbon was determined by a persulfate digestion/infrared detection method on an acidified sample that had been purged of inorganic carbon using nitrogen.
Results	96-h E_{C50} = 169 mg ASA/L 95% confidence limits: 114 and 256 mg ASA/L 96-hr NOEC = 8.1 mg ASA/L
Remarks	
Findings`	All mysids exposed to nominal concentration of 1000 mg ASA/L died during the 24 hour period. Partial mortality was seen at test concentrations of > 27 mg ASA/L. Mysids exposed to 8.1 mg ASA/L showed no signs of treatment related effects. The salt water mysid 96 hour LC50 value for ASA was 169 mg/L, the 95% confidence limits were 114 and 256 mg/L, and the slope of the concentration response curve was 2.0. Based on visual interpretation of the mortality data, the 96 hour no mortality concentration was 8.1 mg ASA/L.
Data Quality	(1) Reliable without restriction

References

D. Murphy, G.T. Peters, “ASA: A 96-Hour Static Renewal Acute Toxicity Test with the Salt Water Mysid (*Mysidopsis Bahia*), Wildlife International, Ltd. Project Number 219A-102A, Sponsored by Ethyl Corporation, 1991.

Other

2.5 Acute Aquatic Toxicity to Fish

2.5.1 Acute Aquatic Toxicity to Fish

Test Substance	C1618 ASA: alkenylsuccinic anhydride
CAS #	Mixture: 32072-96-1, 28777-98-2, 53520-67-5
Chemical Name	Mixture of hexadecenylsuccinic anhydride, octadecenylsuccinic anhydride, eicosenylsuccinic anhydride
Remarks:	Purity: 99.82% active ingredient
Method	
Method Guideline	ASTM Standard E 729-88, "Standard Practice for Conducting Acute Toxicity Tests with Fishes, Macroinvertebrates, and Amphibians '
Test Type	Acute Aquatic Toxicity
GLP (Y/N)	Yes
Year	1991
Species/Strain	Sheepshead Minnow, *Cyprinodon variegatus*
Exposure period/duration	96 hours
Analytical monitoring	Yes
Statistical methods	The 96 hour LC50 was determined by visual inspection of the mortality data.
. Remarks field for test conditions (fill as applicable)	
Test Species:	Juvenile sheepshead minnows were obtained from Wildlife International, Ltd. cultures. All fish were from the same source and year class, and the standard length of the longest fish was no more than twice that of the shortest. Average length of the ten control organisms was 21 mm; average weight of control animals was 0.21 grams. Loading, defined as total wet weight per liter of test solution, was 0.33 grams of fish per liter. Test organisms were acclimated for approximately 52 hours prior to the test. 20 organisms were exposed to each concentration.
Test System:	Each WSF was prepared daily by adding the appropriate amount of test substance to 20 gallon aquaria, which were filled with 15 L of salt water, and stirred gently overnight with magnetic stirrers. After stirring, the solutions were allowed to settle for two hours and the water soluble fractions were siphoned from the middle of the aquaria and delivered to the test chambers. Test chambers were Teflon lined, 25 L polyethylene aquaria filled with 10 L of test solution. The test chambers were randomly positioned in a temperature-controlled environmental chamber designed to maintain a temperature of 22 +/- 1'C.
Test Conditions:	A static renewal test was conducted in that there was daily renewal of test solution. pH and dissolved oxygen content of the water in treatment and control aquaria were measured at 24 hour intervals before and after renewal.

Light:	Fluorescent lights that emitted wavelengths similar to natural sunlight provided a light intensity of approximately 110 foot-candles at water surface. Light cycle was controlled to 16 hours of light and 8 hours of darkness.
Test temperature:	Tests were conducted at a target temperature of 22+/-1'C.
Dilution Water:	Natural seawater collected from Indian River Inlet, Delaware. Salt water was filtered through a sand filter and stored in a 37,800 L tank. Aeration using spray nozzles and filtration (0.2 um) removed organisms and particulates prior to introduction to test system. Salinity and pH of negative control water at beginning of test were 26 0/00 and 8.2 respectively.
Test Levels:	Negative Control and nominal concentrations of 100, 300 and 1000 mg/L WSF TOC measurements were made at the beginning and at 24 hour intervals to verify concentrations.
Method of calculating mean measured concentrations:	not applicable
Exposure period:	96 hours
Analytical monitoring:	Samples of 125 ml were analyzed by a TOC method. Total carbon was determined by a persulfate digestion/infrared detection method on an acidified sample that had been purged of inorganic carbon using nitrogen.

Results

96-hr E_{C50} > 1000 mg ASA/L
96-hr NOEC = 1000 mg ASA/L

Remarks

Findings: All fish exposed to nominal concentration of 1000 mg ASA/L survived for the length of the test and showed no signs of treatment related effects. Based on visual interpretation of the mortality data, the 96 hour no mortality concentration was 1000 mg ASA/L.

Data Quality (1) Reliable without restriction

References

D. Murphy, G.T. Peters, "ASA: A 96-Hour Static Renewal Acute Toxicity Test with the Sheepshead Minnow *(Cyprinodon variegatus)*, Wildlife International, Ltd. Project Number 219A-101, Sponsored by Ethyl Corporation, 1991.

Other

3.0 Toxicity Category: Alkenyl Succinic Anhydride

3.1 Acute Toxicity

3.1.1 Acute Oral Toxicity

3.1.1.1 Acute Oral Toxicity

Test Substance	***C***12 ASA
CAS #	CAS# 25377-73-5
Chemical Name	Succinic anhydride,dodecenyl-
Remarks	Test material purity not provided.
Method	
Method/Guideline Followed	OECD Guideline 401
Test Type	Acute oral toxicity
GLP (Y/N)	N
Year (Study Performed)	1978
Species/Strain	Rats/ Sherman-Wistar
Sex	Male
No. of animals/dose	5
Vehicle	None
Route of administration	Oral (intragastric)
Dose level	1, 2, 4, 8 and 16 g/kg
Dose volume	Not Provided
Vehicle control group:	None
Chemical analysis of dosing solution	No
Remarks field for test conditions	(Note: This study was conducted several years prior to the establishment of this test guideline. This report provides a summary of study findings. Individual data are not presented. Single administration of the test material was given intragastrically to five fasted male rats at each dose level. The animals were observed for signs of toxicity or behavioral changes on the day of treatment and throughout the 14-day observation period. Individual weights were recorded immediately prior to dosing and prior to termination. The surviving animals were euthanized at the conclusion of the observation period. Gross autopsies were performed on all animals.)
Results	LD50 =2.9 (2-4) g/kg (males)
Remarks	During the first three days of study all animals treated at the 4, 8 and 16 g/kg dose levels died. No deaths were observed at the 1 and 2 g/kg dose levels. No clinical signs of toxicity were observed at 1 g/kg. At 2 g/kg the animals were lethargic and had an oily appearance for up to 48 hours post dosing. All animals at the 4, 8 and 16 g/kg dose levels were severely depressed prior to death. No body weight effects occurred at 1 or 2 g/kg. Body weight data was not available at higher dose levels due to the observed mortality. No test material related macroscopic findings were evident.
Conclusions	The test article, when administered to 5 male rats/dose group, had an acute oral LD50 of 2.9 g/kg.

Data Quality	(1) Reliable with restriction Restriction due to the fact that this is a summary report..

References

Other	Summary taken from ACC HERTG panel Robust Summary "Alkenyl Succinic Anhydrides", Update Nov. 22, 2002

3.1.1.2 Acute Oral Toxicity

Test Substance	C_{16-18} ***ASA***
CAS#	Mixture: 32072-96-1, 28777-98-2, 53520-67-5
Chemical Name	Mixture of hexadecenylsuccinic anhydride, octadecenylsuccinic anhydride, eicosenylsuccinic anhydride
Remarks	Test material purity: 98% as ASAs
Method	
Method/Guideline Followed	
Test Type	Acute oral toxicity, Limit test
GLP (Y/N)	Y
Year (Study Performed)	1985
Species/Strain	Rats/ Sprague Dawley
Sex	Male and Female
No. of animals/dose	5 male, 5 female
Vehicle	None, administered as received
Route of administration	Oral by gavage
Dose level	5 grams/kg
Dose volume	5 ml/kg
Vehicle control group:	None
Chemical analysis of dosing solution	No
Remarks field for test conditions	Single administration of the test material was given by gavage to five fasted male and five female rats at each dose level. The animals were observed for signs of toxicity or behavioral changes on the day of treatment and throughout the 14-day observation period. Individual weights were recorded immediately prior to dosing and prior to termination. The surviving animals were euthanized at the conclusion of the observation period. Gross autopsies were performed on all animals.
Results	LD50 > 5 g/kg (males and females)
Remarks	No deaths were observed at the 5 g/kg dose level. Signs observed included diarrhea and wetness of the anogenital region. Body weights increased over the 14 day recovery period.. No test material related macroscopic findings were evident.

Conclusions	The test article, when administered to 5 male rats/dose group, had an acute oral LD50 of > 5 g/kg.
Data Quality	(1) Reliable without restriction
References	V. T. Mallory, "Acute Oral Toxicity Study in Rats (14 day), PH 402-ET-008-84, C16-18 ASA, Lot # Type III", Pharmakon Research International, Inc., sponsored by Ethyl Corporation, 1985.
Other	

3.2 Acute Dermal Toxicity

3.2.1 Acute Dermal Toxicity

Test Substance	C_{16-18} ASA
CAS#	Mixture: 32072-96-1, 28777-98-2, 53520-67-5
Chemical Name	Mixture of hexadecenylsuccinic anhydride, octadecenylsuccinic anhydride, eicosenylsuccinic anhydride
Remarks	Test material purity 98% for ASAs
Method	
Method/Guideline Followed	
Test Type	Acute dermal toxicity, Limit test
GLP (Y/N)	Y
Year (Study Performed)	1985
Species/Strain	Rabbits/ Albino New Zealand White
Sex	Male and Female
No.of animals/dose	5 male, 5 female
Vehicle	None, administered as received
Route of administration	Dermal, to clipped, abraded skin site, occluded with gauze, rubber dam
Dose level	5 grams/kg
Dose volume	N/A
Vehicle control group:	None
Chemical analysis of dosing solution	No
Remarks field for test conditions	Single administration of the test material was applied dermally to five male and five female rabbits at each dose level. Sites were abraded before application of test article, and then occluded with gauze, a rubber dam, and ace bandage. After 24 hours of application, the occlusion was removed, and the test sites washed. The animals were observed for signs of toxicity or behavioral changes at 2 and 4 hours on the day of treatment and throughout the 14-day observation period. Individual weights were recorded immediately prior to dosing and prior to termination. The surviving animals were euthanized at the conclusion of the observation period. Gross autopsies were performed on all animals.

Results	LD50 > 5 g/kg (males and females)
Remarks	No deaths were observed at the 5 g/kg dose level. Signs observed included slight to moderate erythema and edema and fissuring of the skin at the site of application. Mean body weights increased for males and stayed the same for females over the 14 day recovery period.. At terminal necropsy, white foci were observed on all lobes of the liver of one animal.
Conclusions	The test article, when administered to 5 male and five female rabbits/ dose group, had an acute oral LD50 of > 5 g/kg.
Data Quality	Reliable without restriction.
References	V.T. Mallory, "Acute Dermal Toxicity Study in Rabbits. PH 422-ET-009-84, C16-18 ASA, Lot # Type III", Pharmakon Research International, Inc., sponsored by Ethyl Corporation, 1985.
Other	

3.3 Acute Inhalation Toxicity

3.3.1 Acute Inhalation Toxicity

Test Substance	3-(dodecenyl) dihydro-2,5 furandione
CAS #	CAS# 25377-73-5
Chemical Name	Succinic anhydride,dodecenyl-
Remarks	Test material purity not provided.
Method	
Method/Guideline Followed	
Test Type	Acute inhalation toxicity, limit test
GLP (Y/N)	Not known
Year (Study Performed)	1982
Species/Strain	Rats/ Sprague Dawley
Sex	5 Male, 5 Female
No. of animals/dose	5
Vehicle	None
Route of administration	Inhalation
Dose level (concentration)	5.3 mg/l nominal 1.22 mg/l calculated
Duration of exposure	4 hours
Vehicle control group:	None
Chemical analysis of dosing solution	No
Remarks field for test Conditions	Two male and two female rats died when exposed for 4 hours to a nominal concentration of 5.3 mg/l C12 ASA. Thus, LC50 for 4 hour exposure is greater than 1.2 mg/l calculated. Clinical signs observed included labored breathing, transient urinary incontinence, alopecia, eye irritation, and body weight loss. No treatment related alterations were seen at gross necropsy.

Results	***4 hour*** LC50	> 1.22 mg/l

Remarks

Conclusions The test article, when administered to rats for 4 hours by inhalation had an LC50 > 1.22 mg/l

Data Quality (1) Reliable with restriction. Restriction due to the fact that this is a summary report.

References Information taken from EPA/OTS Document Number 888100369, TSCA Sect. 8E, recorded 4/19/82, study conducted by Food and Drug Research Laboratories, for Buffalo Color Corporation.

3.4 Primary Dermal Irritation

3.4.1 Primary Dermal Irritation

Test Substance	***C_{16-18} ASA***
CAS#	Mixture: 32072-96-1, 28777-98-2, 53520-67-5
Chemical Name	Mixture of hexadecenylsuccinic anhydride, octadecenylsuccinic anhydride, eicosenylsuccinic anhydride
Remarks	Test material purity: 98% for ASAs
Method	
Method/Guideline Followed	Draize, 1959, and FHSA 16 CFR 1500.
Test Type	Primary Dermal Irritation
GLP (Y/N)	Y
Year (Study Performed)	1985
Species/Strain	Rabbits/Albino New Zealand White
Sex	Male and Female
No.of animals/dose	3 male, 3 female
Vehicle	None, administered as received
Route of administration	Dermal, to clipped, abraded or non-abraded skin site, occluded with gauze, rubber dam
Dose level	0.5 ml/site
Dose volume	0.5 ml/site
Contact time	24 hours
Vehicle control group:	None
Chemical analysis of dosing solution	No

Remarks field for test conditions

Single administration of the test material was applied dermally to three male and three female rabbits at each dose level. Four sites per animal were prepared by clipping the hair. Two sites were abraded before application of test article; two sites were left intact. Sites were then occluded with gauze, a rubber dam, and ace bandage. After 24 hours of application, the occlusion was removed,

	and the test sites wiped. The animals were observed for signs of erythema and edema and scored according to the Draize scale at 24 and 72 hours after application of treatment and on days 4 and 7. Individual weights were recorded immediately prior to dosing and prior to termination. The surviving animals were euthanized at the conclusion of the observation period
Results	Primary Irritation Index = 2.65
Remarks	No deaths were observed in the test. Signs observed included slight to moderate erythema at 24 and 48 hours, and on day 4. Slight edema of the skin at the site of application was seen at 24 and 72 hours and persisted through day 6. Mean erythema and edema scores were 1.83 and 1.33; and 1.16 and 1.0 for 24 and 72 hours respectively. On day 7, all scores returned to normal and the study was terminated. Mean body weights increased over the course of the study. .
Conclusions	The test article, when administered to 3 male and 3 female rabbits/dose group for 24 hours, caused a primary irritation index of 2.65, which was interpreted as a dermal irritant.
Data Quality	(1) Reliable without restriction

References

V. T. Mallory, "Primary Dermal Irritation Study in Rabbits. PH 420-ET-011-84, C16-18 ASA, Lot # Type III", Pharmakon Research International, Inc., sponsored by Ethyl Corporation, 1985.

Other

3.5 Acute Eye Irritation

3.5.1 Acute Eye Irritation

Test Substance	C_{16-18} ASA
CAS#	Mixture: 32072-96-1, 28777-98-2, 53520-67-5
Chemical Name	Mixture of hexadecenylsuccinic anhydride, octadecenylsuccinic anhydride, eicosenylsuccinic anhydride
Remarks	Test material purity 98% for ASAs
Method	
Method/Guideline Followed	Draize, 1959, and FHSA 16 CFR 1500.
Test Type	Acute Eye Irritation
GLP (Y/N)	Y
Year (Study Performed)	1985
Species/Strain	Rabbits/Albino New Zealand White
Sex	Male and Female
No. of animals/dose	3 male, 3 female
Vehicle	None, administered as received
Route of administration	Directly into eye, no washout

Dose volume	0.1 ml
Vehicle control group:	None
Chemical analysis of dosing solution	No
Remarks field for test conditions	Single administration of the test material was applied into the right eye of three male and three female rabbits. Eyes were examined at 1, 24, 48, and 72 hours and 7 days after treatment. The treated eyes were observed for signs of erythema and edema of the conjunctiva, eversion of the eyelids, ulceraton of the cornea or stippling and opacity, and inflammation of the iris. Grading of the irritation was according to the method of Draize (1965). Classification would be considered as non-irritant if 0 or 1 rabbit had "positive scores" at any time point, and irritant if 4 to 6 animals had positive scores. Individual weights were recorded immediately prior to dosing and prior to termination. The surviving animals were euthanized at the conclusion of the observation period
Results	***Classification was considered irritant***
Remarks	No deaths were observed in the test. Positive ocular scores (for iris, values of "1") were seen at the one hour observation. Scores returned to normal, and the study was terminated on day 7. Mean iris score at 1 hour was 0.87 (some folding). Mean conjunctival score was 1.0 at one hour (some swelling). At 24 hours, all animals had "0" scores for cornea, iris, and conjunctiva except one animal had a value of "1" for edema. All scores for 48 hours and beyond were "0" for all endpoints. Mean body weights increased over the course of the study.
Conclusions	The test article, when administered ocularly to 3 male and 3 female rabbits/dose group, produced threshold values for iris at one hour, which was interpreted an eye irritant under the conditions of the test. In many classification systems, these observations would be interpreted as nonirritant.
Data Quality	(1) Reliable without restriction
References	V. T. Mallory, "Acute Eye Irritation Study in Rabbits. PH 421-ET-008-84, C16-18 ASA, Lot # Type III", Pharmakon Research International, Inc., sponsored by Ethyl Corporation, 1985.
Other	

3.6 Skin Sensitization

3.6.1 Skin Sensitization

Test Substance	C_{16-18} ASA
CAS#	Mixture: 32072-96-1, 28777-98-2, 53520-67-5
Chemical Name	Mixture of hexadecenylsuccinic anhydride, octadecenylsuccinic anhydride, eicosenylsuccinic anhydride
Remarks	Test material purity: 98% for ASAs
Method	
Method/Guideline Followed	Ritz and Buehler, 1980
Test Type	Delayed contact sensitization -Guinea Pigs
GLP (Y/N)	Y
Year (Study Performed)	1987
Species/Strain	Guinea pigs/ Hartley albino
Sex	Male and Female
No. of animals/dose	4 male, 4 female for irritation study 10 male, 10 female for test article 5 male, 5 female for two naïve control groups
Vehicle	Acetone
Route of administration	Dermal for irritation, induction and challenge
Dose level	Irritation test: Undiluted, 50%, 25%, 10%, 5%, 2.5%, 1.0% and 0.5% formulations in acetone Induction: 50% w/v in acetone Primary challenge: 10% w/v in acetone Rechallenge: 3% w/v in acetone
Dose volume	0.3 ml/site
Contact time	6 hours, under Hill Top Chamber
Vehicle control group:	No
Chemical analysis of dosing solution	No
Remarks field for test conditions	

In the irritation test, a single administration of the test material was applied dermally to sites clipped of hair on four male and four female guinea pigs. Each animal had 4 sites exposed to a different concentration of test article on a gauze patch. Sites were covered with a Hill Top chamber, which was covered with tape and a rubber dam. After 6 hours of application, the occlusion was removed, and the animals returned to their cages. On the day following application, the clipped sites were depilated with chemical hair remover, and the sites scored for severity of response at 24 hours and 48 hours. The animals were observed for signs of erythema and edema and scored either 0 (no reaction), +/- (slight patchy erythema), 1 (slight confluent or moderate patchy edema), 2 (moderate erythema), and 3 (severe erythema with or without edema).

For induction of sensitization, the upper left quadrant of the backs of guinea pigs were clipped of hair. On the following day, moistened patches were applied, to the test group, the animals restrained as previously described, and the animals returned to their cages. Patches moistened with test article were applied to the skin in the same manner once a week for three applications. The same site was clipped on the day before application, and the restraint periods were six hours on each occasion.

For primary challenge two weeks after the last of the induction applications, a fresh application site was prepared by clipping the lower left quadrant of the backs of test and naïve control animals. The next day, a challenge patch was applied to each guinea pig in the test and control groups. Each animal was restrained for 6 hours as before, and the animals returned to their cages. On the next day, sites were depilated and scored for severity of response at least two hours later and for a 48 hour reading. Scores of "1" or greater in the test group were considered to be indicative of sensitization providing grades of less than 1 were found in the naïve control group. If the naïve group had grade`1, scores were considered positive in the test animals if greater than the control group scores. In this test, no control animal had a score of "1" in the challenge or rechallenge phase. Seven test animals had a score of "1" at challenge; 9 animals had a score of "1" or greater on rechallenge. The incidence and severity of responses were more pronounced in the test group indicating that a sensitization response had been elicited.

Conclusions The test article, when administered to guinea pigs according to the method of Ritz and Buehler, caused delayed contact hypersensitivity of the skin.

Data Quality (1) Reliable without restriction

References: Ritz, H.L, and Buehler, E.V, (1980), In Current Concepts in Cutaneous Toxicity (V.A. Drill and T. Lazar, eds.) pp. 25-40, Academic Press, New York.

Other: Buehler, E.V., "Delayed Contact Hypersensitivity Study in Guinea Pigs of: ASA Alkenylsuccinic Anhydride" for Ethyl Corporation, Hill Top Research Project No. 86-0873-21, Hill Top Research, Inc., 1986.

3.6.2 Skin Sensitization

Test Substance Dodecenyl Succinic Anhydride
CAS# CAS #27859-58-1
Chemical Name Dodecenyl Succinic Anhydride (C12 ASA)

Remarks Test material purity: 98% for ASAs

Method

Method/Guideline Followed Ritz and Buehler, 1980
Test Type Delayed contact sensitization -Guinea Pigs
GLP (Y/N) Y

Year (Study Performed)	1986
Species/Strain	Guinea pigs/ Hartley albino
Sex	Male and Female
No.of animals/dose	4 male, 4 female for irritation study 10 male, 10 female for test article 5 male, 5 female for two naïve control groups
Vehicle	Acetone
Route of administration	Dermal for irritation, induction and challenge
Dose level	Irritation test: Undiluted, 50%, 25%, 10%, 5%, 2.5%, and 1.0% formulations in acetone Induction: 25% w/v in acetone Primary challenge: 5% w/v in acetone Rechallenge: 3 % w/v in acetone
Dose volume	0.3 ml/site
Contact time	6 hours, under Hill Top Chamber
Vehicle control group:	No
Chemical analysis of dosing solution	No

Remarks field for test conditions

In the irritation test, a single administration of the test material was applied dermally to sites clipped of hair on four male and four female guinea pigs. Each animal had 4 sites exposed to a different concentration of test article on a gauze patch. Sites were covered with a Hill Top chamber, which was covered with tape and a rubber dam. After 6 hours of application, the occlusion was removed, and the animals returned to their cages. On the day following application, the clipped sites were depilated with chemical hair remover, and the sites scored for severity of response at 24 hours and 48 hours. The animals were observed for signs of erythema and edema and scored either 0 (no reaction), +/- (slight patchy erythema), 1 (slight confluent or moderate patchy edema), 2 (moderate erythema), and 3 (severe erythema with or without edema).

For induction of sensitization, the upper left quadrant of the backs of guinea pigs were clipped of hair. On the following day, moistened patches were applied, to the test group, the animals restrained as previously described, and the animals returned to their cages. Patches moistened with test article were applied to the skin in the same manner once a week for three applications. The same site was clipped on the day before application, and the restraint periods were six hours on each occasion.

For primary challenge two weeks after the last of the induction applications, a fresh application site was prepared by clipping the lower left quadrant of the backs of test and naïve control animals. The next day, challenge patch was applied to each guinea pig in the test and control groups. Each animal was restrained for 6 hours as before, and the animals returned to their cages. On the next day, sites were depilated and scored for severity of response at least two hours later and for a 48 hour reading. Scores of “1” or greater in the test group were considered to be indicative of sensitization providing grades of less than 1 were found in the naïve control group. If the naïve group had grades of “1” or greater, the reactions in the test group that exceeded the most severe reactions in the control group were presumed to be indicative of sensitization.

For rechallenge, eight days after the primary challenge, all of the original animals were single patch rechallenged. Ten previously unexposed naïve animals were identically treated to serve as a new naïve control group. The right rear quadrant was used for rechallenge. Depilation and observation procedures were the same as described for primary challenge.

Individual weights were recorded immediately prior to dosing and prior to termination. The surviving animals were euthanized at the conclusion of the observation period

Results

No deaths were observed in the test. The incidence of grade “2” responses or greater in the test group exposed to 25% for induction, and 5% at primary challenge was greater for the test animals (13 of 20) compared to the naïve challenge group (0 of 10). The incidence and severity of responses in the test group were more pronounced than the responses of the naïve group, suggesting sensitization had occurred.

At rechallenge with 3% test article in acetone, the incidence of grade “1” responses or greater in the test group (17 of 20) was greater than that in the naïve control group (0 of 10). The incidence and severity of responses were more pronounced in the test group indicating that a sensitization response had been elicited.

Conclusions

The test article, when administered to guinea pigs according to the method of Ritz and Buehler, caused delayed contact hypersensitivity of the skin.

Data Quality

(1) Reliable without restriction

References:

Ritz, H.L, and Buehler, E.V., (1980), In Current Concepts in Cutaneous Toxicity, (V.A. Drill and T.Lazar, eds.) pp. 25-40, Academic Press, New York.

Other:

Buehler, E.V., “Delayed Contact Hypersensitivity Study in Guinea Pigs of: DODECENYL SUCCINIC ANHYDRIDE C12 ASA” for Ethyl Corporation, Hill Top Research Project No. 86-0873-21, Hill Top Research, Inc., 1986.

3.6.3 Skin Sensitization

Test Substance $C_{16\text{-}18}$ ASA

CAS# Mixture: 32072-96-1, 28777-98-2, 53520-67-5

Chemical Name	Mixture of hexadecenylsuccinic anhydride, octadecenylsuccinic anhydride, eicosenylsuccinic anhydride
Remarks	Test material purity: 98% for ASAs
Method	
Method/Guideline Followed	Magnusson and Kligman, 1969
Test Type	Guinea Pig Sensitization Maximization Test
GLP (Y/N)	Y
Year (Study Performed)	1985
Species/Strain	Guinea pigs/ Hartley albino
Sex	Male and Female
No.of animals/dose	4 male, 4 female for irritation study 10 male, 10 female for test article 3 male, 3 female for positive control 2 male, 2 female for vehicle control
Vehicle	0.9% saline for intradermal injection 80% ethanol for topical applications
Route of administration	Intradermal for first induction Dermal for irritation, second induction, challenge and rechallenge
Dose level, test article	Irritation test: Undiluted, 50%, 25%, 10%, 5%, 4%, 3%, 2%, and 1.0% formulations Intradermal rangefinder: 5%, 4%, 3%, 2%, 1% Intradermal induction: 1% Topical induction: 5% Primary challenge: 1% Rechallenge: 0.5%
Dose level, positive control	DNCB 0.1% for intradermal induction DNCB 0.1% topical and challenge
Dose volume	0.1 ml/site for intradermal injection
Frequency of administration	Once each for ID and topical induction Once each for topical challenge and rechallenge
Vehicle control group:	Yes
Chemical analysis of dosing solution	No
Remarks field for test conditions	

In the intradermal rangefinder test, a single administration of the test material was applied intradermally to sites clipped of hair on two male and two female guinea pigs. Each animal had 6 sites exposed to a different concentration of test article. The animals were observed for signs of erythema and edema and were scored at 24 hours as either 0 (no reaction), +/- (slight patchy erythema), 1 (slight confluent or moderate patchy edema), 2 (moderate erythema), and 3 (severe erythema with or without edema). Based on results, the dose chosen for intradermal injection was 1.0%.

For the dermal range finding study, eight unexposed animals were topically induced with different concentrations of test article. Skin on the sides was shaved of hair, test article applied, and sites wrapped for 24 hours. Readings were made at 24 hours after unwrapping and followed the above described scoring. The dose chosen for topical induction was 5%. Challenge dose was chosen to be 1% and rechallenge dose 0.5%.

For intradermal induction of sensitization, the shoulders of guinea pigs were clipped of hair. All intradermal injections for these groups (test article group, vehicle group, and positive control groups) were given in this shoulder area. Three injections were given in each site: 1) 0.1 ml of Freund's Complete Adjuvant 2) 0.1 ml of test article, vehicle or positive control and 3) 0.1 ml test article, vehicle or positive control mixed with Freund's complete adjuvant.

Topical induction was conducted seven days after intradermal induction. The sites were clipped of hair. Filter paper (2 x 4 cm) was saturated with experimental material, vehicle or positive control substance and applied to the injection site area and occluded with a rubber dam under a bandage. Bandaging was removed after 48 hours

For primary challenge two weeks after the last of the induction applications, a fresh application site was prepared by clipping the left and right flanks of test and naïve control animals. Challenge patches were applied to each guinea pig in the test and control groups under occlusion. Twenty four hours later, the sites were wiped clean and clipped of hair. Three hours later, sites were scored for severity of response and again 24 hours later. Kligman's classification scheme modified to reflect a treatment group of twenty animals was used to rank the substances in order of their sensitization capacity. According to the percentage of animals sensitized, the substance was assigned to one of five classes ranging from weak (0-8%, grade 1) to extreme (81-100%, grade V) regardless of the intensity of the response. Magnusson and Kligman do not consider sensitization grade 1 as significant.

For rechallenge, six days after the primary challenge, all of the original animals were single patch rechallenged.

Individual weights were recorded immediately prior to dosing and prior to termination. The surviving animals were euthanized at the conclusion of the observation period

Results	No deaths were observed in the test. The positive control group (DNCB) showed a positive sensitization response. The treated group (C1618 ASA, 1%) produced a 35% positive response corresponding to sensitization grade III (moderate, 29-64%). Rechallenge with 0.5%ASA caused positive responses in 15% of the test animals corresponding to a sensitization grade II (mild, 9-28%).
Conclusions	The test article, when administered to guinea pigs according to the method of Magnusson and Kligman, caused sensitization of the skin.
Data Quality	(1) Reliable without restriction
	V.T. Mallory, "Guinea Pig Sensitization Maximization Test (Magnusson-Kligman) C1618 ASA" PH 423-ET-001-84: Pharmakon Research International, Inc., sponsored by Ethyl Corporation, 1986.

4.0 MUTAGENICITY:

4.1 Bacterial Mutagenicity

Test Substance	$C_{16\text{-}18}$ ASA
CAS#	Mixture: 32072-96-1, 28777-98-2, 53520-67-5
Chemical Name	Mixture of hexadecenylsuccinic anhydride, octadecenylsuccinic anhydride, eicosenylsuccinic anhydride
Remarks	Test material purity 98% for ASAs
Method	
Method/Guideline Followed	Revised methods for the Salmonella Mutagenicity Test, Maron, DM and B.N Ames, 1983
Test Type	Bacterial Mutagenicity: Plate Incorporation Assay
GLP (Y/N)	Y
Year (Study Performed)	1985
Species/Strain	Salmonella typhimurium, TA 1535, TA 1537, TA1538, TA 98, TA 100
Source:	Dr. Bruce Ames, University. of California, Berkeley, California
Vehicle	Acetone
Positive Controls:	Sodium Azide: TA 1535, TA 100, without activation 10 ug/plate 9-aminoacridine: TA 1537 without activation

	150 ug/plate 2-nitrofluorene: TA 98, TA 1538 without activation 5 ug/plate 2-aminoanthracene: all strains with activation 5.0 ug/plate
Dose levels:	0.5, 1.6, 5.0, 16 and 50 ug ASA/plate
Vehicle control group:	
Chemical analysis of dosing solution	No
Remarks field for test conditions	
Test organism preparation	Frozen stock cultures were prepared from frozen master cultures and, after 10-12 hours growth period, aliquoted in 1 ml culture media into Nunc vials, and quick frozen before being stored at a minimum of –60'C. Fresh cultures were prepared by thawing a vial of frozen working stock cultures of each tester strain and transferring the culture to 25 ml Oxoid Nutrient Broth #2, and grown for approximately 10 hours at 37'C in an incubator/shaker. After incubation, samples were diluted 1:4 in distilled water and optical densities observed. Historical data has shown that optical densities of 0.4 are representative of cells in late exponential or early stationary phase of growth. Tester strains were checked monthly for appropriate genetic markers.
Negative and Positive controls:	Tester strains TA 1535, TA 1537, TA 1538, TA 98 and TA 100 were plated in triplicate with the appropriate solvent, both with and without metabolic activation to obtain background lawn and revertant colony formation to serve as negative solvent controls. All tester strains were also run in triplicate with known positive response chemicals.
Top Agar:	Used as an overlay was reconstituted into a molten state, and supplemented with 0.5 mM histidine and 0.5 mM biotin at a volume of 0.1 ml per ml of agar, and maintained at 45'C until use. All negative and positive tubes and control plates, and all compound treated plates, and all compound treated tubes and plates were prepared in triplicate. Tubes were prepared with 2 ml aliquots of top agar, 0.1 ml of tester strain, and 0.1 ml of the appropriate concentration of test compound. The tubes were vortexed, and the contents poured onto minimal glucose plates. The sample was evenly distributed on the plate and the top agar overlay allowed to harden.
Metabolic Activation System:	S-9 fraction of rat liver homogenate from Aroclor 1254-treated Sprague Dawley rats. S-9 fraction was thawed on the day of use and 0.5 ml of S-9 mix added to tubes which

required metabolic activation, in addition to the preceding top agar ingredients. Tubes were then vortexed and poured on minimal glucose plates. Plates were allowed to harden.

Process:	Within an hour of plating, plates were inverted and placed in a dark 37’C incubator. Plates were incubated for 48-72 hours, checked for uniform background lawn, and scored by counting revertant colonies on an electronic colony counter interfaced with a computer for data acquisition.
Results:	There were no observed increases in mutation frequencies in strains TA 1535, TA 1537, TA 1538, TA 98, and TA100 of Salmonella typhimurium both with and without metabolic activation at doses of 0.5, 1.6, 5.0, 16, and 50 ug/plate. All solvent and positive controls were within the acceptable limits of mean historic data.
Conclusion:	The test article was negative for mutagenicity within the conditions of this test in strains TA 1535, TA 1537, TA 1538, TA 98, and TA100 of Salmonella typhimurium both with and without metabolic activation at doses of 0.5, 1.6, 5.0, 16, and 50 ug/plate.

Data Quality (1) Reliable without restriction

References

T.R. Barfknecht, “Ames Salmonella/Microsome Plate Test (EPA/OECD). PH 301-ET-004-84, ASA, Lot # Type III”, Pharmakon Research International, Inc., sponsored by Ethyl Corporation, 1985.

Other

4.2 In vitro Mammalian Cell Mutagenicity

4.2.1 Unscheduled DNA Synthesis

Test Substance	C_{16-18} ASA
CAS#	Mixture: 32072-96-1, 28777-98-2, 53520-67-5
Chemical Name	Mixture of hexadecenylsuccinic anhydride, octadecenylsuccinic anhydride, eicosenylsuccinic anhydride
Remarks	Test material purity 98% for ASAs
Method	
Method/Guideline Followed	Revised method of Williams, 1978
Test Type	Rat Hepatocyte Primary Culture/DNA Repair Test
GLP (Y/N)	Y
Year (Study Performed)	1985

Species/Strain	Rat/ Fischer-344
Vehicle	DMSO
Positive Controls:	2-acetamidofluorene at 10^{-6} M
Dose levels evaluated :	5, 20 and 50 ug ASA/well
Vehicle control group:	Yes
Chemical analysis of dosing solution	No
Remarks field for test conditions	
Hepatocyte preparation	Male Fisher rats were anesthetized with sodium Nembutal by intraperitoneal injection. The livers were exposed surgically, perfused, and removed. The livers were excised, and isolated hepatocytes prepared. Freshly isolated hepatocytes were treated with 20 ul of ASA at 0.05, 0.1, 0.5, 1, 5, 10, 50, 100, 500, and 1000 ug/well in 2 mL of media.
Negative and Positive controls:	An acetone group, an untreated control, and a 2AAF (2-acetamidofluorene) group were evaluated concurrently with the treatment groups.
Process:	Hepatocytes were treated with test article, fixed on microscope cover slides, stained, dipped, and developed. Unscheduled DNA repair synthesis, evidenced by a net increase in black silver grains in the nucleus, was quantified by determining nuclear and background grain counts for 25 cells per slide, or as many cells as possible up to 25 in the presence of toxicity. An automatic colony counter with a microscope attachment was used for the counts. This value was determined by taking a nuclear count and the average of three adjacent cytoplasmic counts. A positive test would be based on production of a mean grain count of five or greater than the vehicle control mean grain count and a statistically significant difference between test article treated cells and the vehicle control in the number of cells with net nuclear grain counts greater than zero.
Results:	Cytotoxicity was produced at 100, 500 and1000 ug/well. Test article did not cause an increase in mean net nuclear counts over the acetone control treated cells at any dose level counted (50, 10 and 5 ug/well. All solvent and positive controls were within the acceptable limits of mean historic data.

Conclusion: The test article was negative for mutagenicity within the conditions of this test. ASA was not able to produce a mean grain count of five or greater than the vehicle control mean grain count, and no statistical difference between the ASA treated cells and vehicle control in number of cells with a net nuclear grain count greater than zero was produced. A dose response increase in net nuclear counts or cells greater than zero was not demonstrated for ASA.

Data Quality Reliable without restriction

References

D. E. Johnson, "Genetic Toxicology Rat Hepatocyte Primary Culture/DNA Repair Test," C16-18 alkenyl succinic anhydride, ASA, ", Ethyl Corporation Technical Center. 1984.

Other